PEACH Calibration, Inc.
RT. 2, BOX 141-C
McMINNVILLE, OREGON 97128
(503) 472-1860

INSTRUCTION MANUAL

TYPE 251 s/n____

INSTRUCTION MANUAL

TYPE 251 s/n____

EXACT electronics
a division of DYNATECH NEVADA INC
2000 ARROWHEAD DR., P.O.BOX 1925
CARSON CITY, NEVADA 89701
(702)883-3400/(800)648-7952
Telex 170054

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IF YOUR INSTRUMENT DOES NOT OPERATE

PLEASE

1. Check operating procedure in manual for proper set-up.
2. Check fuse and power supply voltages.
3. Consult the brief trouble shooting guide at the beginning of the MAINTENANCE section of this manual.
4. Call your EXACT representative or the factory collect.

A new instrument should operate properly on arrival and no-one wishes this more than Exact. Many things keep this from happening in every case and if yours is the exception, you should be inconvenienced as little as possible. Some people like to find a trouble themselves, others prefer not to touch an instrument without representation from the manufacturer. **YOUR WARRANTY WILL IN NO WAY BE AFFECTED BY YOUR EFFORT TO FIND THE TROUBLE AND PUT YOUR INSTRUMENT IN EARLY OPERATION.** We leave it to your judgment and offer the services of our representatives and our factory to give you the assistance you need.

WARRANTY

All Exact instruments are fully guaranteed against defective materials and workmanship for one year. Replacement parts requests should be clearly identified and the instrument serial number given. The needed parts will be air shipped to you within 24 hours.

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INDEX

SECTION I - OPERATION

1.1 SPECIFICATIONS
1.2 FRONT PANEL FAMILIARITY
1.3 PURPOSE
1.4 OPERATION

SECTION II - MAINTENANCE

2.1 BLOCK DIAGRAM
2.2 CHASSIS LAYOUT
2.3 CIRCUIT DESCRIPTION
2.4 TROUBLESHOOTING PROCEDURE
2.5 RESISTANCE/DC VOLTAGE CHARTS
2.6 WAVEFORM CHART

SECTION III - CALIBRATION

3.1 POWER SUPPLY
3.2 TIMING
3.3 TRIANGLE WAVEFORM LINEARITY
3.4 SINE WAVEFORM LINEARITY
3.5 RAMP WAVEFORM LINEARITY
3.6 COSINE WAVEFORM LINEARITY
3.7 DC LEVELS AND OUTPUT AMPLITUDES
3.8 INPUT TRIGGER CHECKS

SECTION IV - PARTS LIST

SECTION V - - - - - - - - - - - - - - - - - - CIRCUIT DIAGRAM

SECTION I OPERATION

1.1 - SPECIFICATIONS

1.2 - FRONT PANEL FAMILIARITY

1.3 - PURPOSE

1.4 - OPERATION

1.5 - APPLICATIONS

TYPE 251 FUNCTION GENERATOR

TYPE 251 FUNCTION GENERATOR

TYPE 251 FUNCTION GENERATOR

This Function Generator can be externally triggered, and produces seven separate outputs simultaneously. Five of the output waveforms - square, triangle, sine ramp and cosine - are fixed amplitude auxiliary outputs. The sixth output (Main) is switched to provide any one of the five function-waveforms with adjustable amplitude and dc reference level. The seventh output is a trigger-output signal for use by associated equipment. In externally triggered mode, one input trigger pulse produces one complete cycle at all seven outputs, simultaneously. The cosine waveform, which leads the sine waveform by 90°, is especially valuable for servo and electro-mechanical work. The square, triangle, sine and ramp waveforms befit the 251 to serve as a general purpose Function Generator, well suited for circuit design, equipment check-out and calibration, quality control, and other production and systems applications.

SIMULTANEOUS OUTPUTS

All outputs of the 251 occur simultaneously and are synchronized throughout the entire frequency range of the generator. Phase relationship is unique in that the triangle and sine waveform peaks occur at rise and fall points of the square waveform.

MAIN OUTPUT

The main output is switched to any one of the five function waveforms and provides amplitude adjustment from 300mv to over 25 volts p-p. Dc reference level is adjustable from -15 to +15 volts, and is referenced to chassis ground or, by removing a shorting-strap, is referenced to circuit ground which is then isolated from the chassis.

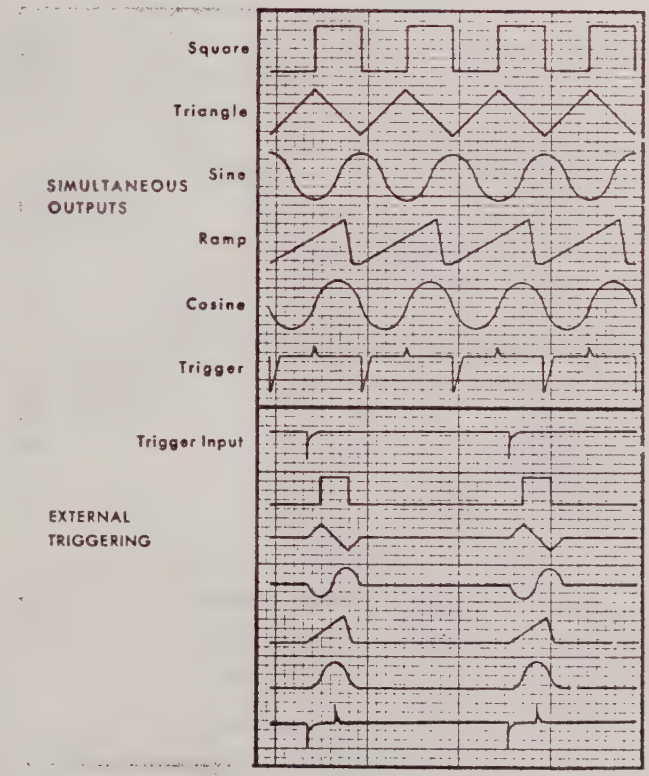
EXTERNAL TRIGGERING

The 251's flexibility is clearly demonstrated when using externally-triggered operation. In this mode, one input trigger pulse produces one complete cycle at all outputs, simultaneously. A pushbutton permits manual triggering of the outputs for one-shot applications. Triggered waveforms are adjustable (timing controls) from 100 usecs to over 16 minutes duration.

PHYSICAL CHARACTERISTICS

The 251 is 5-1/4" high by 15-1/2" wide, and has a net weight of only 21 pounds. The 251 generator can be supplied in rackmount version (251RM) at no additional cost. Front panel is of dark grey color, with silkscreened white panel designations. End bells and cabinet are medium grey. All exterior finishes are oven baked for durability.

- * SIMULTANEOUS OUTPUTS
- * SQUARE-TRIANGLE-SINE RAMP-COSINE
- * 300mv to 25 volts P-P
- * 0.001cps to 10kc
- * TRIGGERED or FREE-RUNNING



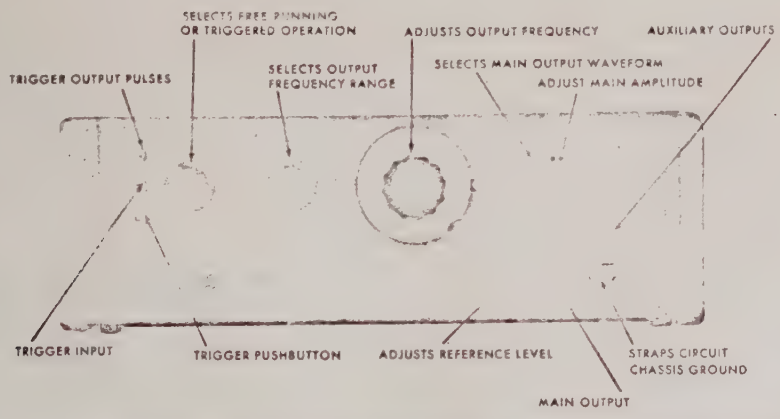
EXACT Electronics, Inc

EXACT ELECTRONICS INC.

455 S.E. 2nd Avenue, Hillsboro, Oregon 97123

printed in U.S.A.

8-251-1 7-64



SPECIFICATIONS

MAIN OUTPUT

Amplitude * . . . . . 300 mv to 25 volts p-p (min)
. . . . . 25 volts into 5K load
Stability/Repeatability ‡ . . . 50 mv (10 min), 300 mv (24 hrs)
Amplitude Change with Frequency ‡ . . . . . 0.5% to 1 kc
. . . . . 1% to 10 kc
Amplitude Change with Function . . . . . 2% max
DC Reference Level Range *
. . . . . -15 to +15 volts or switched to 0v
Frequency Range . . . . . 0.001 cps to 10 kc
Frequency Deviation from Absolute . . . . . 3% max
Long Term Frequency Stability . . . . . ±1%

EXTERNAL TRIGGERING

Trigger Input Pulse . . . . . 1 usec risetime (min)
. . . . . -10 volts amplitude (min)
. less than 1 usec delay from -10v point
. . . . . and start of waveform

POWER REQUIREMENTS

Line Voltage . . . . . 105 to 125 or 200 to 250 vac
Line Frequency . . . . . 50 to 400 cps
Power . . . . . 150 watts

TRIGGER OUTPUT

Waveform . . . . . Differentiated squarewave
Amplitude . . . . . -25v (min)

PHYSICAL CHARACTERISTICS

Weight . . . . . 20 lbs net, 27 lbs gross
Volume . . . . . 2 cu ft gross
Dimensions . . . . . 15-1/2w X 5-1/4h X 13d

SQUARE WAVEFORM

Risetime . . . . . 5 usecs or faster
Symmetry 99.5%
Overshoot . . . . . 1% max
Droop . . . . . 1% max

TRIANGLE WAVEFORM

Linearity 99.5%
Symmetry 99.5%

SINE WAVEFORM

Total Distortion . . . . Less than 2% over entire freq. range

RAMP WAVEFORM

Linearity 99.5%
Fall Time . . . . . Less than 6% to 1 kc
Less than 10% to 10 kc
Dead Time † . . . . . Less than 6% to 1 kc
Less than 10% to 10 kc

COSINE WAVEFORM

Total Distortion . . . . . Less than 2% over entire freq. range

AUXILIARY OUTPUTS

Amplitude * . . . . . 30 volts p-p (min)
. . . . . 30 volts into 7K load
Stability/Repeatability . . . . . (same as main)
Amplitude Change with Frequency . . . . . (same as main)
DC Reference Level . . . . . 0 volts (fixed)
Frequency Range . . . . . Synchronized with main

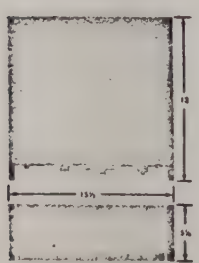
* Max Current . . . . . 15 ma @ +15vdc reference level
3 ma @ -15vdc reference level

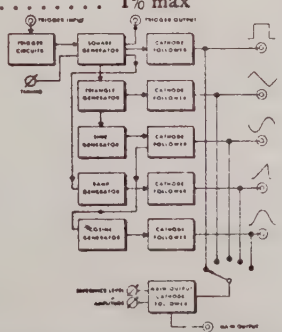
† Ramp dead time can be reduced to less than 1% at any one frequency (internal adjustment).

‡ Main Output amplitude and reference level stability is somewhat broader when cosine waveform is selected. If cosine requirements are critical, consult factory for exact tolerances.

PRICE $685.00

F.O.B. Factory . . . . . ////////





For the location of your nearest representative, consult Electronic Engineers Master.

eem File 2900

EXACT ELECTRONICS INC

Telephone (503) 648-6661 TWX: 503-821-6927

[illegible] THE FOLLOWING OPERATIONAL [illegible] SPECIFICATIONS

EXTERNAL TRIGGERING

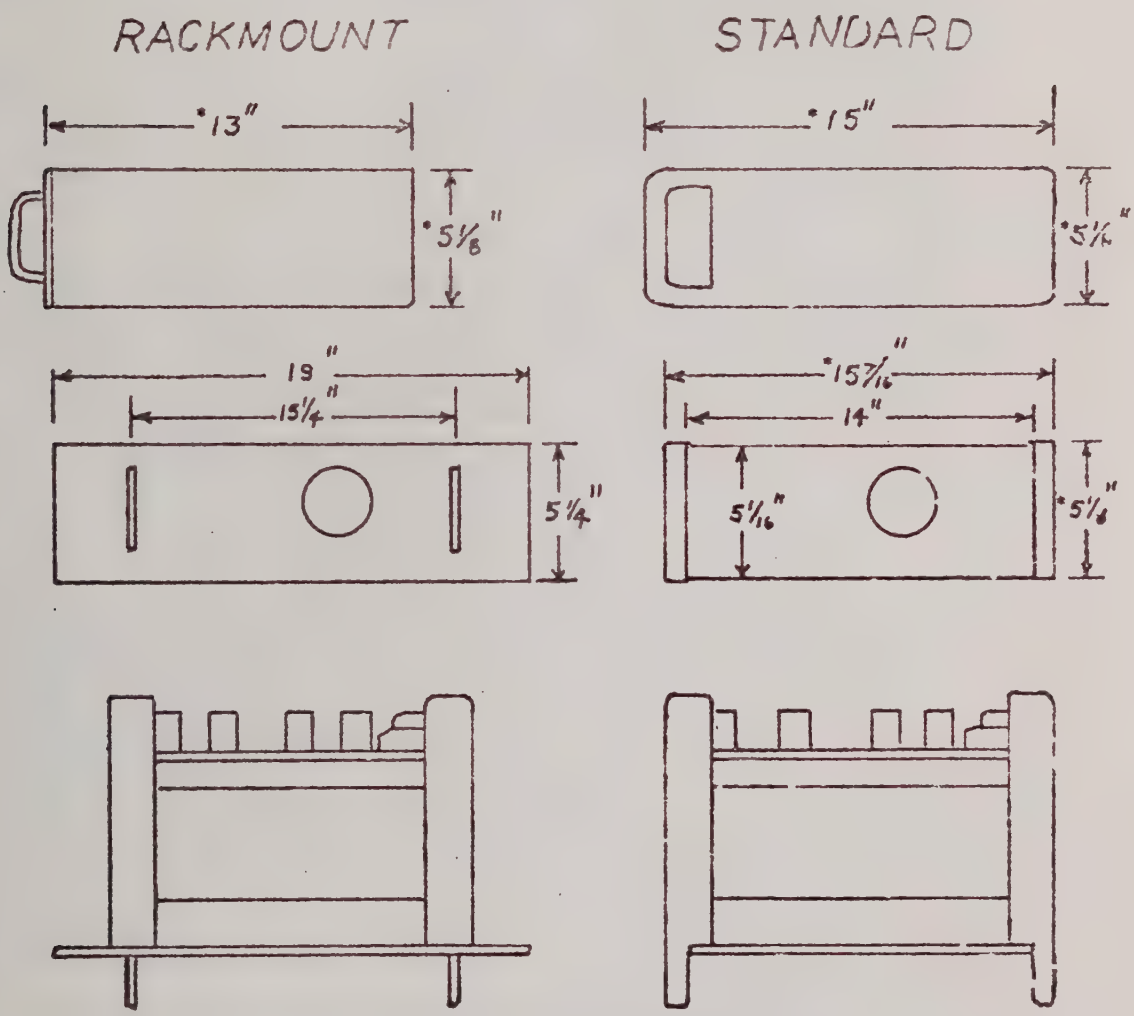
TRIGGER INPUT PULSE SHOULD READ ~15 VOLTS AMPLITUDE.

MAIN OUTPUT

FREQUENCY DEVIATION FROM ABSOLUTE SHOULD READ
DIAL ACCURACY .... 2% MAXIMUM DIAL READING.

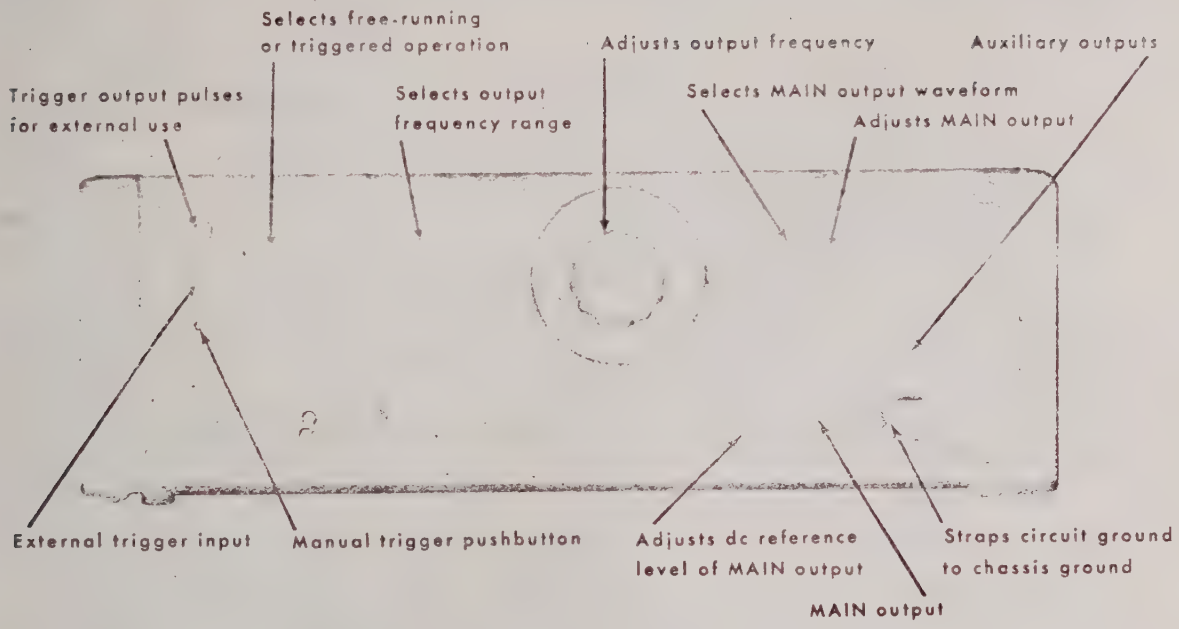
1.1 SPECIFICATIONS (CONTINUED)

DIMENSIONS:



* THESE MEASUREMENTS ARE CORRECT WITHIN ±1/16" DUE TO THE CASTING OF THE ALUMINUM ENDBELLS.

1.2 FRONT PANEL FAMILIARITY


Selects free-running or triggered operation
Adjusts output frequency
Auxiliary outputs
Trigger output pulses for external use
Selects output frequency range
Selects MAIN output waveform
Adjusts MAIN output
External trigger input
Manual trigger pushbutton
Adjusts dc reference level of MAIN output
Straps circuit ground to chassis ground
MAIN output

1.2.1. TIMING

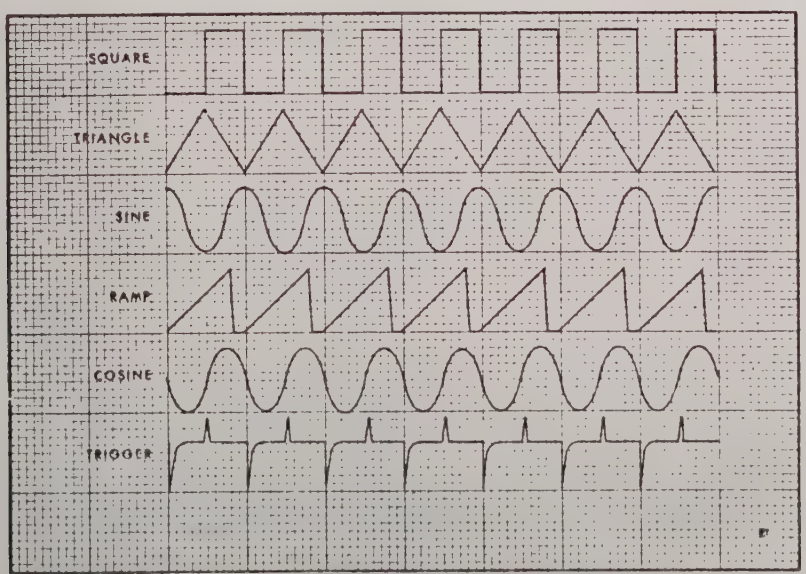
(a) TIMING RANGE
.001 CPS to 10,000 CPS

(b) TIMING ACCURACY
Maximum 3% deviation between any combination of multiplier and dial setting and absolute time.

(c) TIMING STABILITY
Maximum 1% deviation from original set frequency over a 24 hour period. Timing is more critical at X1 end of the CYCLES/SEC dial.

1.2.2. OUTPUT

(a) TIME-PHASE RELATION OF OUTPUT



1.2.2. OUTPUT (CONTINUED)

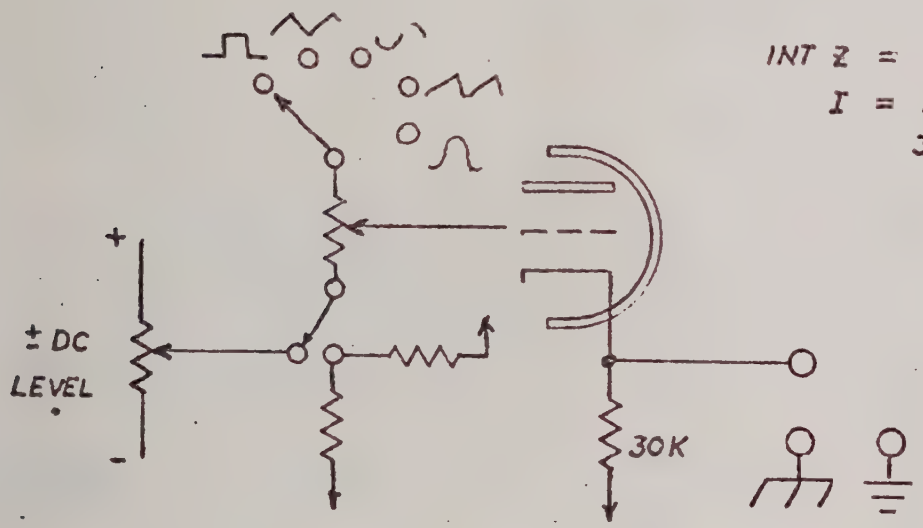
(B) MAIN OUTPUT

(1) AMPLITUDE ..... 300MV TO AT LEAST 25V PP

(2) DC COMPONENT ... FIXED AT ZERO VOLTS OR VARIABLE FROM -13V TO +13V (MINIMUM RANGE)

(3) STABILITY ..... 50MV SHORT TERM
150MV LONG TERM

(4) IMPEDANCE .....



INT Z = APPROX 200 Ω
I = 15MA MAX
3MA AT -13V
DC LEVEL

(C) POLARITY

CIRCUIT GROUND CAN BE ISOLATED FROM CABINET GROUND BY REMOVING THE INTERCONNECTING STRAP. THE OUTPUT WILL NOW BE FLOATING. IF YOU DO NOT LOAD THE OUTPUT, THERE WILL BE SOME HUM PICKUP AND A 1 µFD CAPACITOR SHOULD BE PLACED BETWEEN THE TWO GROUND POSTS.

MAXIMUM ELEVATION POTENTIAL -- 500V

(D) DC LEVEL

THE ABOVE SKETCH ILLUSTRATES THE OPERATION AND RANGE OF THE ± DC LEVEL POTENTIOMETER. WHEN THIS POTENTIOMETER IS IN THE "SWITCHED" OR "0" POSITION, THE WAVEFORMS SHOULD HAVE A CENTER 0 DC LEVEL. INTERNAL ADJUSTMENTS ON ALL WAVEFORMS ASSURE THAT THIS CAN ALWAYS BE TRUE. THE SINE, SQUARE, RAMP AND COSINE OFFSETS ARE SIMILAR TO THE ABOVE TRIANGLE OFFSETS.

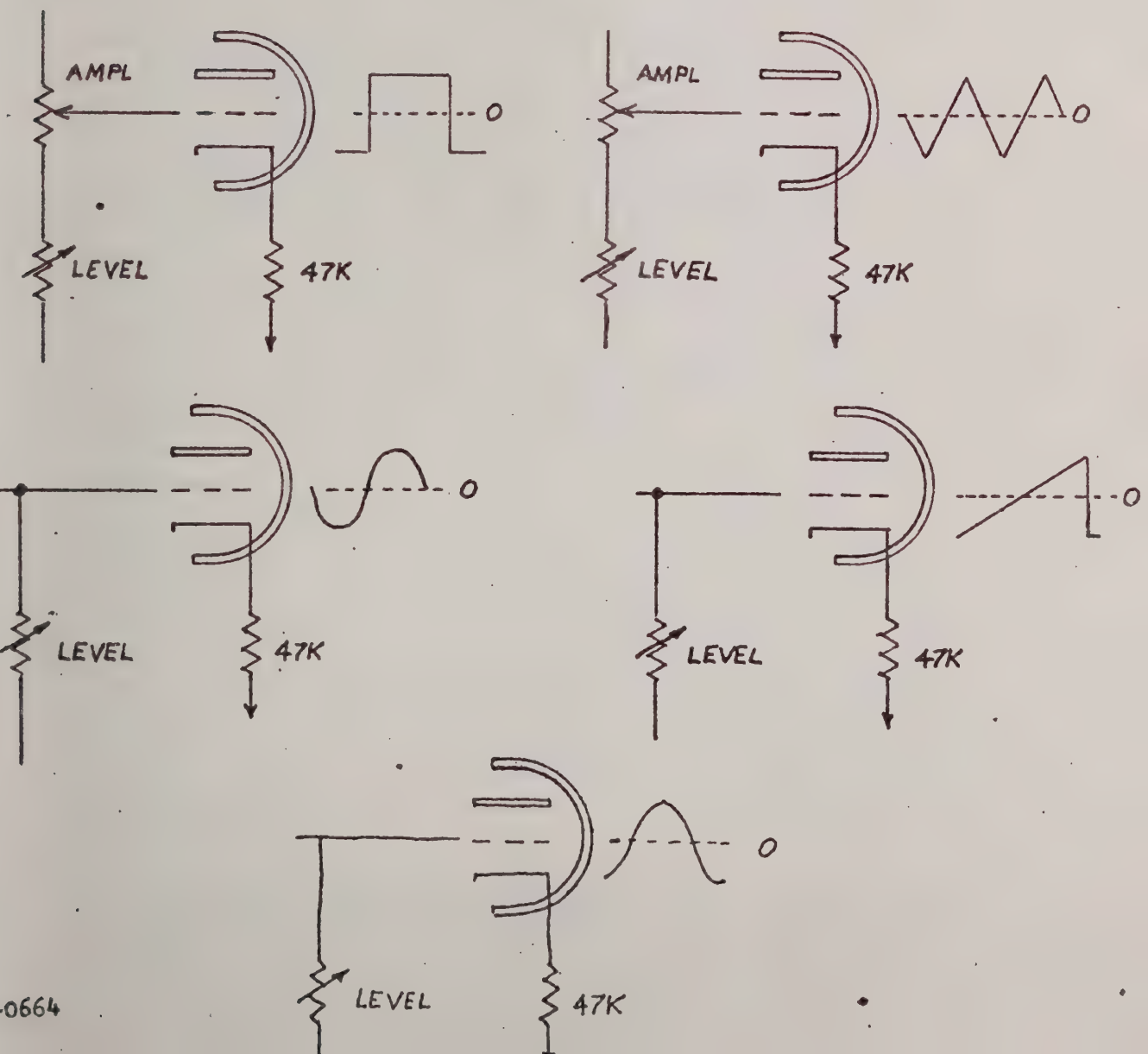
1.2.2 OUTPUT (CONTINUED)

(E) AMPLITUDES

THE AMPLITUDES OF ALL WAVEFORMS ARE THE SAME WITHIN 2%. INTERNAL ADJUSTMENTS ON THE SQUARE AND TRIANGLE WAVEFORMS ASSURE THAT THEIR AMPLITUDES CAN BE ADJUSTED TO WITHIN 2% OF THE SINE WAVE AMPLITUDE.

(F) SIMULTANEOUS OUTPUTS

THE SIMULTANEOUS OUTPUT WAVEFORMS ARE AT A FIXED DC LEVEL (INTERNAL ADJUSTMENT). THE AMPLITUDES OF THE SQUARE AND TRIANGLE WAVEFORMS ARE INTERNALLY ADJUSTABLE.



1.3 PURPOSE

THE GENERAL PURPOSE OF THE TYPE 251 IS TO GENERATE SQUARE, SINE, TRIANGLE, RAMP AND COSINE WAVEFORMS OVER A CONTINUOUSLY VARIABLE FREQUENCY RANGE OF 0.001 CPS TO 10,000 CPS. THESE WAVEFORMS ARE AVAILABLE SIMULTANEOUSLY FROM THE DESIGNATED JACKS ON THE RIGHT HAND SIDE OF THE FRONT PANEL OR SINGLY AS SELECTED FROM THE MAIN OUTPUT JACK. THESE WAVEFORMS MAY BE CONTINUOUS, EXTERNALLY TRIGGERED OR TRIGGERED BY THE MANUAL PUSHBUTTON.

1.4 OPERATION

FOR FIRST-TIME OPERATION, THE FOLLOWING PROCEDURE SHOULD BE USED:

(A) CHECK THE STRAP BETWEEN THE GROUND POSTS.

(B) SET THE POWER SWITCH TO ON.

(C) ALLOW A TEN-MINUTE WARM-UP PERIOD.

(D) SET THE OUTPUT SWITCH TO TRIANGLE WAVEFORM.

(E) TURN OUTPUT ATTENUATOR (RED CONCENTRIC KNOB) FULLY CLOCKWISE.

(F) SET THE FREQUENCY MULTIPLIER AND CYCLES/SEC DIAL TO THE DESIRED FREQUENCY.

(G) SET THE ±DC LEVEL TO 0 (SWITCH CLOSED) POSITION OR TO THE OUTPUT LEVEL DESIRED.

(H) CONNECT THE MAIN OUTPUT AND/OR SIMULTANEOUS OUTPUT TO THE SYSTEM, CIRCUITS AND THE OSCILLOSCOPE, ETC.

(J) SET THE TRIGGER SWITCH TO INTERNAL.

(K) CONNECT THE TRIGGER OUT JACK THE THE EXTERNAL TRIGGER INPUT OF THE MONITOR OSCILLOSCOPE.

1.5 APPLICATIONS

(A) GENERAL WAVEFORM SOURCE FOR RESEARCH, ANALOG COMPUTERS AND SYSTEMS CHECKING.

(B) THE LOW FREQUENCY SQUARE WAVEFORM FOR RESPONSE CHECKS.

(C) THE TRIANGLE WAVEFORM AS A RASTER GENERATOR.

(D) THE RAMP WAVEFORM AS A SWEEP VOLTAGE FOR MONITOR OSCILLOSCOPES, RECORDERS, ETC.

(E) LINEARITY CHECKING OF INSTRUMENTS OR SYSTEMS BY VARYING THE DC LEVEL, AMPLITUDE, OR FREQUENCY WHILE HOLDING ONE OR BOTH OF THE OTHER PARAMETERS CONSTANT.

1.5 APPLICATIONS (CONTINUED)

(F) AS A DELAY TRIGGER GENERATOR (TRIGGER THE TYPE 251 EXTERNALLY AND USE THE SQUARE OR RAMP FALL, WHICH IS VARIABLE OVER THE ENTIRE TIMING RANGE) TO TRIGGER THE SCOPE OR OTHER EQUIPMENT.

(G) SERVO SYSTEMS CHECKING.

(H) WAVEFORMS CAN BE DIRECTLY MIXED BY PATCHING TOGETHER THE SIMULTANEOUS AND MAIN OUTPUTS AT THE FRONT PANEL TO PRODUCE COMPLEX WAVEFORMS. IF YOU WISH TO OFFSET SOME OF THESE SIMULTANEOUS OUTPUTS, INTERNAL ADJUSTMENTS CAN BE MADE.

SECTION II MAINTENANCE

2.1 - BLOCK DIAGRAM

2.2 - CHASSIS LAYOUT

2.3 - CIRCUIT DESCRIPTION

2.3.1 Power Supply
2.3.2 Square Waveform Generator
2.3.3 Triangle Waveform Generator
2.3.4 Sine Waveform Generator
2.3.5 Ramp Waveform Generator
2.3.6 Cosine Waveform Generator
2.3.7 Main Output
2.3.8 Simultaneous Outputs
2.3.9 External Trigger

2.4 - TROUBLESHOOTING PROCEDURE

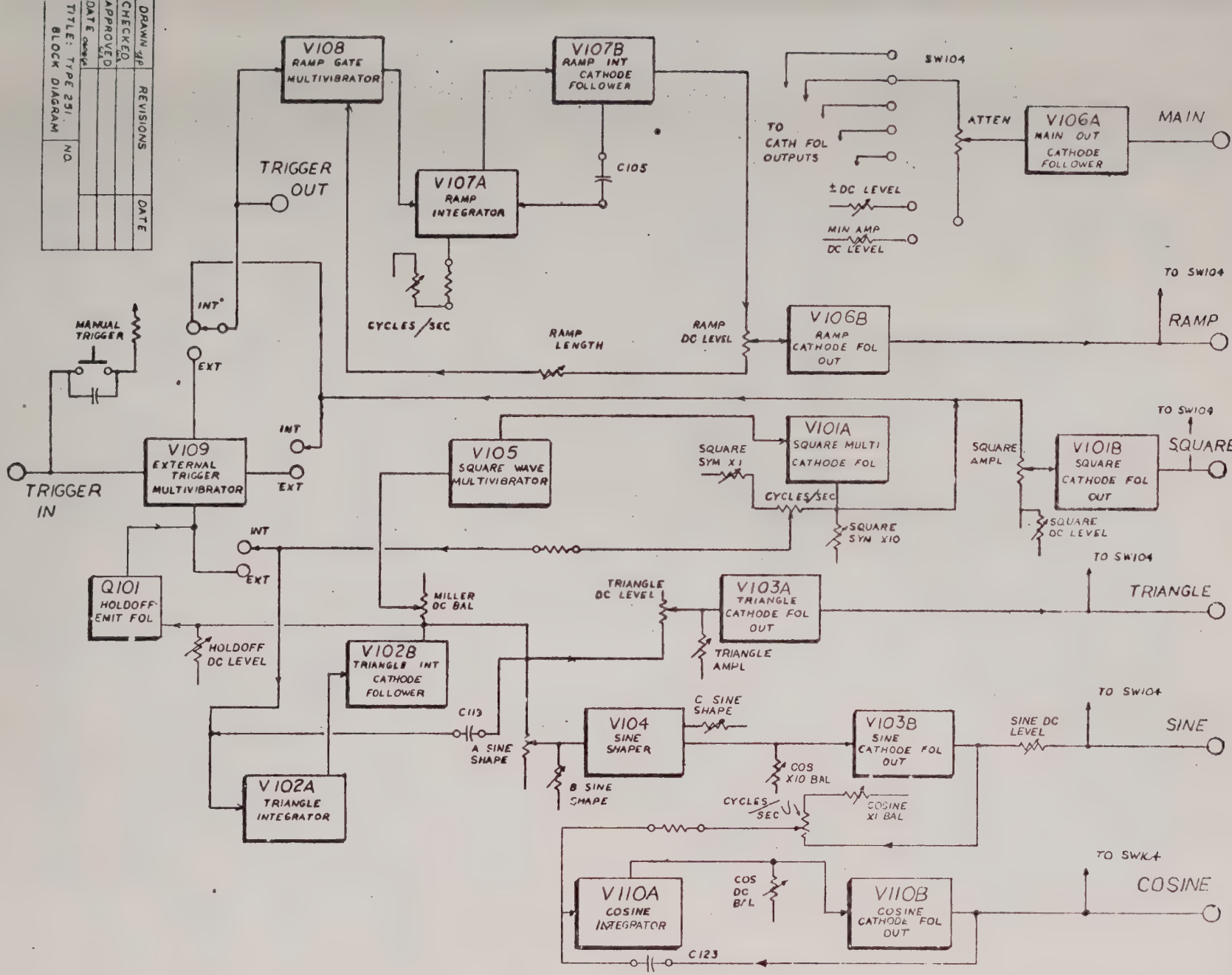
2.4.1 Power Supply
2.4.2 Square Waveform
2.4.3 Triangle Waveform
2.4.4 Sine Waveform
2.4.5 Ramp Waveform
2.4.6 Cosine Waveform
2.4.7 DC Levels

2.5 - - - - - - - - - - - - - - - - - - - RESISTANCE AND DC VOLTAGE CHARTS

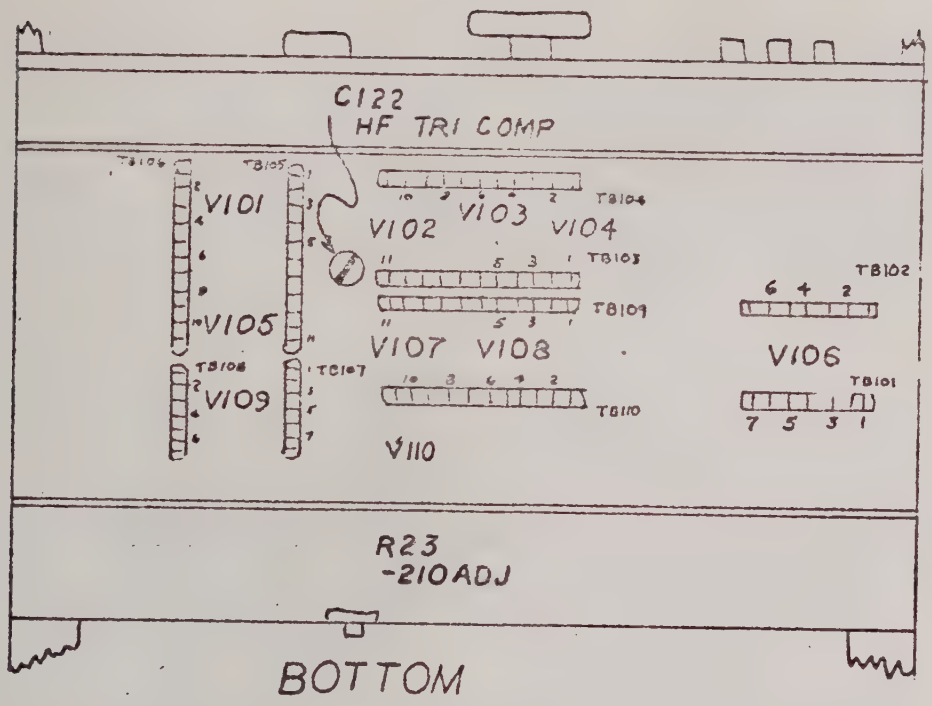
2.5.1 Power Supply Resistance and DC Voltage Chart
2.5.2 Main Chassis Resistance and DC Voltage Chart

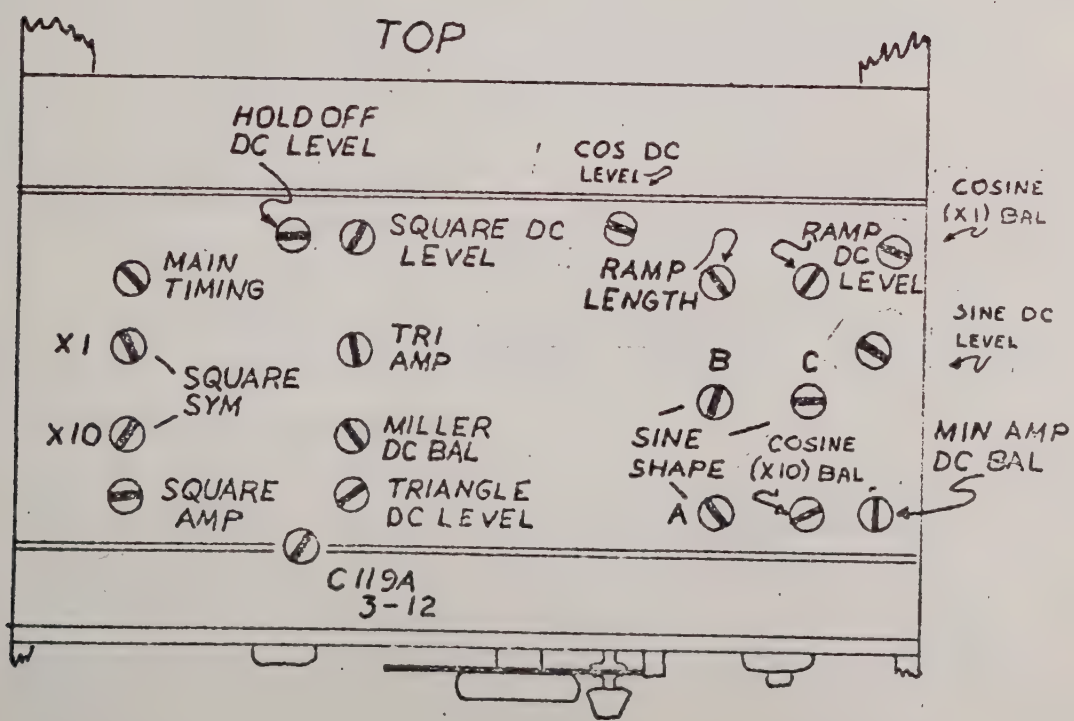
2.6 - - - - - - - - - - - - - - WAVEFORM AMPLITUDE AND DC LEVEL CHART

CAUTION To assure drift-free operation within the instrument capabilities, aged tubes should be used for replacement.


TITLE: TYPE 251 BLOCK DIAGRAM
NO.
DATE
REVISIONS
DRAWN
CHECKED
APPROVED
V108 RAMP GATE MULTIVIBRATOR
V107B RAMP INT CATHODE FOLLOWER
V107A RAMP INTEGRATOR
C105
CYCLES/SEC
TRIGGER OUT
SW104
TO CATH FOL OUTPUTS
ATTEN
V106A MAIN OUT CATHODE FOLLOWER
MAIN
±DC LEVEL
MIN AMP DC LEVEL
TO SW104
RAMP
V106B RAMP CATHODE FOL OUT
RAMP LENGTH
RAMP DC LEVEL
INT
EXT
MANUAL TRIGGER
V109 EXTERNAL TRIGGER MULTIVIBRATOR
TRIGGER IN
V105 SQUARE WAVE MULTIVIBRATOR
V101A SQUARE MULTI CATHODE FOL
SQUARE SYM X1
CYCLES/SEC
SQUARE SYM X10
SQUARE AMPL
V101B SQUARE CATHODE FOL OUT
SQUARE
SQUARE DC LEVEL
Q101 HOLDOFF EMIT FOL
HOLDOFF DC LEVEL
MILLER DC BAL
V102B TRIANGLE INT CATHODE FOLLOWER
TRIANGLE DC LEVEL
V103A TRIANGLE CATHODE FOL OUT
TRIANGLE
TRIANGLE AMPL
V102A TRIANGLE INTEGRATOR
C113
A SINE SHAPE
B SINE SHAPE
V104 SINE SHAPER
C SINE SHAPE
V103B SINE CATHODE FOL OUT
SINE DC LEVEL
SINE
COS X10 BAL
CYCLES/SEC
COSINE X1 BAL
V110A COSINE INTEGRATOR
COS DC BAL
V110B COSINE CATHODE FOL OUT
TO SWK4
COSINE
C123

2.2 CHASSIS LAYOUT





2.3 CIRCUIT DESCRIPTION

2.3.1 POWER SUPPLY

THE THREE POWER SUPPLIES ARE ALL BASED ON THE SAME PRINCIPLE. A DC AMPLIFIER IS REFERENCED TO A STANDARD VOLTAGE (A 5651 GAS TUBE OR PRECISION DIVIDERS FROM -210V). ANY VARIATION FROM LINE OR LOAD IS AMPLIFIED BY THE DC AMPLIFIER AND PASSED ALONG AS A CONTROL VOLTAGE TO THE SERIES REGULATOR TUBE. THE FILAMENT SUPPLY IS REGULATED BY A TRANSISTOR REFERENCED TO A ZENER DIODE.

2.3.2 SQUARE WAVEFOPM GENERATOR

(A) V105 IS A CATHODE COUPLED MULTIVIBRATOR. ITS OUTPUT (PIN #6) SWINGS FROM BELOW -100V, WHEN V105B IS CONDUCTING, TO A +100V WHEN IT IS CUT OFF. THE TIME DURATION OF EACH HALF-CYCLE IS DETERMINED BY THE TRIANGLE WAVEFORM AT GRID PIN #9 OF V105A. THE TRIANGLE WAVEFORM DETERMINES THE SWITCHING OF THE MULTIVIBRATOR. THE TRIANGLE WAVEFORM MUST ALWAYS PASS THROUGH THE SAME DC LEVELS TO SWITCH V105 AND THEREFORE THIS PARTLY DETERMINES THE TIMING OF THE INSTRUMENT.

(B) THE LOOP GAIN OF THE CATHODE COUPLED MULTIVIBRATOR IS DETERMINED BY ITS CATHODE CURRENT. THIS DETERMINES THE FINAL TIMING AND IS CONTROLLED BY R161.

(C) V101A IS A CATHODE FOLLWER WHOSE OUTPUT PROVIDES FOUR FUNCTIONS:

(1) SQUARE WAVE SYMMETRY (X10), R173 PROVIDES FOR EQUAL VOLTAGE BUT OPPOSITE POLARITY AT X10 END OF CYCLES/SEC DIAL FOR EACH HALF-CYCLE OF V105.

(2) PROVIDES STANDARD SQUARE WAVEFORM TO OUTPUT CATHODE FOLLOWER V101B.

(3) PROVIDES SQUARE WAVEFORM TO MILLER INTEGRATOR TIMING RESISTORS AND CAPACITORS (R134-R136 AND C119 (A-F).

(4) PROVIDES SQUARE WAVEFORM TO RAMP GATE V108 AND "TURN-OFF" VOLTAGE TO EXTERNAL TRIGGER MULTIVIBRATOR, V109.

2.3.3 TRIANGLE WAVEFORM GENERATOR

V102 IS A MILLER INTEGRATOR AMPLIFIER WITH AN ASSOCIATED CATHODE FOLLOWER. THE SYMMETRICAL SQUARE WAVEFORM FROM V101A IS FED TO GRID PIN #2 OF V102A AND THE INTEGRATOR ACTION PRODUCES A TRIANGLE WAVEFORM AT THE CATHODE (PIN #8 OF V102B). TIME CONSTANTS FOR THE INTEGRATOR ARE C119 (A-G), AND R169, R170 AND R171. MILLER DC BAL R188 DETERMINES THE LEVEL AND AMPLITUDE OF THE SIGNAL BEING FED BACK TO THE GRID PIN #9 OF V105.

2.3.4 SINE WAVEFORM GENERATOR

V104 IS A PENTODE WHOSE BIAS CHARACTERISTICS ARE ADJUSTED BY THREE SINE SHAPING ADJUSTMENTS, R185, R193 AND R202. THE LINEAR TRIANGLE WAVEFORM FROM V102B IS SHAPED BY THESE ADJUSTMENTS TO PRODUCE A VERY LOW DISTORTION SINE WAVEFORM AT THE PLATE PIN #5.

SINE ADJ A (R185) CONTROLS THE DC LEVEL OF THE GRID.

SINE ADJ B (R193) CONTROLS THE AMPLITUDE OF THE TRIANGLE WAVEFORM INTO GRID PIN #1 OF V104.

SINE ADJ C (R202) CONTROLS THE SUPRESSOR BIAS OF V104.

2.3.5 RAMP WAVEFORM GENERATOR

V108 IS A CATHODE COUPLED MULTIVIBRATOR WHICH SHAPES THE RELATIVELY SLOW RISE SQUARE WAVEFORM INPUT TO A FAST RISE GATE TO START THE MILLER INTEGRATOR V107A. RUNUP ACTION IS STARTED BY THE GATING PULSE FROM V108. TIMING CONSTANTS ARE R112, R113, R114, R115 AND C105 (A-F). D102 AND D103 RETURN THE TIMING CAPACITOR TO THE PROPER QUIESCENT OPERATING LEVEL AFTER RUNUP.

V107B FURNISHES THE NECESSARY PLATE TO GRID FEEDBACK FOR THE INTEGRATOR AND IS ALSO THE CATHODE FOLLOWER TAKE-OFF TO THE OUTPUT AMPLIFIER.

RAMP LENGTH (R123) DETERMINES THE NECESSARY VOLTAGE LEVEL TO RESET THE GATING MULTI V108 WHICH IN TURN STOPS THE RUNUP AND TERMINATES THE RAMP.

2.3.6 COSINE WAVEFORM GENERATOR

V110 IS A MILLER INTEGRATOR WITH AN ASSOCIATED CATHODE FOLLOWER. V110A, THE PENTODE SECTION, IS USED AS AN INTEGRATOR AMPLIFIER. THE SINE WAVEFORM FROM V103B IS APPLIED TO V110A AND THE INTEGRATOR ACTION DERIVES THE COSINE FUNCTION. SW103 G, H AND J PLACE THE PROPER TIME CONSTANTS IN THE MILLER INTEGRATOR. R111C REDUCES THE AMPLITUDE OF THE SINE WAVEFORM INPUT WHEN THE CYCLES/SEC DIAL IS ROTATED CCW. WHEN THE VARIABLE TIME IS INCREASED FROM 1 TO 10, THE AMPLITUDE OF THE INPUT SINE WAVEFORM IS INCREASED BY A RATIO OF 1 TO 10. THIS ACTION GIVES A NEARLY CONSTANT OUTPUT COSINE WAVEFORM. V110B IS A CATHODE FOLLOWER FURNISHING COSINE WAVEFORM OUTPUT AND INTEGRATOR FEEDBACK TO V110A.

2.3.7 MAIN OUTPUT

V106A IS A CONVENTIONAL CATHODE FOLLOWER. THE PROPER WAVEFORM BEING FED TO THE GRID IS SELECTED BY THE OUTPUT SWITCH, SW104. THE DC LEVEL OF THE CONTROL GRID IS DETERMINED BY:

(A) R130, R134 AND R135 IF ±DC OUTPUT LEVEL SWITCH IS CCW IN SWITCHED POSITION.

2.3.7 MAIN OUTPUT (CONTINUED)

(B) R162 IF ± DC OUTPUT LEVEL SWITCH IS CW FROM SWITCHED POSITION.

2.3.8 SIMULTANEOUS OUTPUTS

V101B, V103A, V103B, V106B AND V110B ARE THE STANDARD CATHODE FOLLOWERS PROVIDING LOW IMPEDANCE OUTPUTS FOR THE INDIVIDUAL SQUARE, TRIANGLE, SINE, RAMP AND COSINE WAVEFORMS. THE SINE WAVEFORM CATHODE FOLLOWER V103B, RAMP WAVEFORM CATHODE FOLLOWER V106B AND COSINE WAVEFORM CATHODE FOLLOWER V110B HAVE DC LEVEL CONTROLS ONLY WHILE THE SQUARE WAVEFORM CATHODE FOLLOWER V101B AND THE TRIANGLE WAVEFORM CATHODE FOLLOWER V103A HAVE BOTH DC LEVEL AND AMPLITUDE CONTROLS.

2.3.9 EXTERNAL TRIGGER

(A) V109 IS A BI-STABLE MULTIVIBRATOR WHOSE OUTPUTS ARE USED TO:

(1) CLAMP THE TRIANGLE WAVEFORM INTEGRATOR GRID (PIN #2 OF V102A) NEAR GROUND LEVEL WHICH STOPS OPERATION OF THE GENERATING CIRCUITS, V105, V101B AND V102B.

(2) PROVIDE A TRIGGER OUT PULSE AND A GATE TO V108 IN EXTERNAL TRIGGER OPERATION.

(B) WHEN THE TRIGGER SWITCH IS IN THE EXTERNAL POSITION, THE FIRST NEGATIVE-GOING PORTION OF THE SQUARE WAVEFORM AT PIN #7 OF V109 WILL TURN OFF THAT SIDE OF THE TUBE. THIS WILL STOP ALL INTERNAL TRIGGERING DUE TO THE CLAMP ACTION AT GRID PIN #2 OF V102A. THE NEGATIVE GOING PORTION OF AN EXTERNAL OR MANUAL TRIGGER AT PIN #2 OF V109 WILL CAUSE THAT HALF OF THE TUBE TO CUT OFF. V109B WILL CONDUCT AND THE CLAMP WILL BE REMOVED. OPERATION WILL CONTINUE FOR ONE CYCLE UNTIL THE FALLING EDGE OF THE SQUARE WAVEFORM AGAIN LOCKS OUT V109. THE HOLD-OFF EMITTER FOLLOWER Q101 PROVIDES A LOW IMPEDANCE FEEDBACK LOOP FROM PIN #8 OF V102B. HOLD-OFF DC LEVEL R213 ADJUSTS THE DC LEVEL AT WHICH LOCKOUT WILL TAKE PLACE. SEE SEC. 3.8.

2.4 TROUBLESHOOTING PROCEDURE

2.4.1 POWER SUPPLY

(A) ALL CIRCUITS DEPEND ON THE REGULATED -210V, +100V AND +250V. THE MORE CRITICAL GENERATING CIRCUITS ALSO DEPEND ON THE -11V FILAMENT REGULATION. ALWAYS CHECK THESE SUPPLIES FOR PROPER VOLTAGE AND BELOW 10MV OF RIPPLE (100MV ON -11V SUPPLY).

(1) FOR -210V PROBLEMS CHECK V1, V2 AND V3; CHECK -210 ADJ R23; CHECK DIODES D9 THROUGH D12.

2.4.1 POWER SUPPLY (CONTINUED)

(2) FOR +100V PROBLEMS CHECK -210V, V3 AND V4, DIVIDER VOLTAGE AT PIN #1 OF V4 AND DIODES D5 THROUGH D8.

(3) FOR +250V PROBLEMS CHECK -210V, V5 AND V6, DIVIDER VOLTAGE AT PIN #1 OF V6 AND DIODES D1 THROUGH D4.

(4) FOR -11V PROBLEMS CHECK Q1, Q2, ZENER DIODE D17 AND DIODES D13 THROUGH D16.

(B) WHEN EXPERIENCING HUM, DRIFT OR JITTER, CHECK THE REGULATION OF THE POWER SUPPLIES AND/OR INSURE THAT THE STRAP IS INSTALLED BETWEEN THE CHASSIS GROUND AND CIRCUIT GROUND TERMINALS.

(C) SHORTED RECTIFIER DIODES MAY CAUSE FUSE BLOWING.

2.4.2 SQUARE WAVEFORM

V105 GENERATES THE SQUARE WAVEFORM. THE FLIP TIME IS DETERMINED BY THE TRIANGLE WAVEFORM PRESENT AT THE GRID (PIN #9) OF V105 WHICH IS DERIVED FROM V102 CATHODE FOLLOWER. PROBLEMS INVOLVING SQUARE WAVEFORM ONLY SHOULD BE TRACED TO V101 AND V105 IN THAT ORDER. IF EXPERIENCING AN UNSYMMETRICAL SQUARE WAVEFORM, VERIFY THAT THE TWO SYMMETRY ADJUSTMENTS ARE CORRECT. (SEE PARA. 3.2.4).

2.4.3 TRIANGLE WAVEFORM

V102 IS A MILLER INTEGRATOR. THE INTEGRATOR OUTPUT IS A POSITIVE AND NEGATIVE GOING VOLTAGE IN THE FORM OF A TRIANGLE WAVEFORM. PROBLEMS INVOLVING TRIANGLE ONLY SHOULD BE TRACED TO V103A, V102, R188 AND R161 SETTINGS IN THAT ORDER.

2.4.4 SINE WAVEFORM

V104 SHAPES THE TRIANGLE WAVEFORM INTO A SINE WAVEFORM. THIS SHAPING DEPENDS ON ACCURATE SYMMETRY OF THE SQUARE AND TRIANGLE WAVEFORMS. THE INPUT DC LEVEL AND AMPLITUDE OF THE TRIANGLE WAVEFORM ARE CRITICAL. ALL PREVIOUS SETTINGS AND CALIBRATION PROCEDURES SHOULD BE CHECKED BEFORE FURTHER TROUBLESHOOTING OF THE SINE WAVEFORM. ONLY THEN SHOULD PROBLEMS BE TRACED TO V103A, V107, SINE SHAPE ADJUSTMENTS (R185, R193, R202) AND SINE DC LEVEL R216 IN THAT ORDER.

2.4.5 RAMP WAVEFORM

V108 IS TRIGGERED BY V105 (INTERNAL TRIGGERING) OR V109 (EXTERNAL TRIGGERING) AND FURNISHES THE GATE FOR MILLER INTEGRATOR V107. PROBLEMS INVOLVING RAMP WAVEFORM ONLY SHOULD BE TRACED TO V106B, V107, V108, RAMP LEVEL AND RAMP LENGTH POTENTIOMETER (R121 AND R123) SETTINGS, AND D102 AND D103 IN THAT ORDER.

2.4.6 COSINE WAVEFORM

V110 GENERATES THE COSINE WAVEFORM THROUGH INTEGRATOR ACTION BY DELAYING THE SINE WAVEFORM 90°. THEREFORE, CORRECT SHAPING OF THE COSINE WAVEFORM DEPENDS ON CORRECT SHAPING OF THE SINE WAVEFORM AT V104. PROBLEMS INVOLVING COSINE WAVEFORM ONLY SHOULD BE TRACED TO V110B, V110A, COSINE X10 BAL AND COSINE X1 BAL (R208 AND R221) SETTINGS, COSINE AMPL C123A, AND COSINE DC LEVEL (R215) SETTINGS.

2.4.7 DC LEVELS

INCORRECT DC LEVELS OF OUTPUT WAVEFORMS MAY BE CAUSED BY INCORRECT INTERNAL DC LEVEL ADJUSTMENTS (SEE PARA. 3.5).

2.5 RESISTANCE AND DC VOLTAGE CHARTS

2.5.1 POWER SUPPLY RESISTANCE AND DC VOLTAGE CHART

(A) RESISTANCE MEASUREMENTS

THE RESISTANCE MEASUREMENTS WERE MADE ON A COLD INSTRUMENT WITH THE CONTROLS SET AS FOLLOWS:

MULTIPLIER	100
CYCLES/SEC DIAL	10
ATTENUATOR	FULL CW
POWER OFF-ON	OFF
TRIGGER	INTERNAL

(B) DC VOLTAGE MEASUREMENTS

(1) THE DC VOLTAGE MEASUREMENTS WERE MADE WITH A VTVM HAVING AN 11 MEGOHM INPUT RESISTANCE. THE INSTRUMENT INPUT VOLTAGE WAS ADJUSTED TO 117 VAC.

(2) THE FUNCTION GENERATOR CONTROLS WERE SET AS FOLLOWS:

MULTIPLIER	100
CYCLES/SEC DIAL	10
ATTENUATOR	FULL CW
POWER OFF-ON	ON
TRIGGER	INTERNAL

2.5.2 MAIN CHASSIS RESISTANCE AND DC VOLTAGE CHART

(A) RESISTANCE MEASUREMENTS

THE RESISTANCE MEASUREMENTS WERE MADE ON A COLD INSTRUMENT WITH CONTROLS SET AS FOLLOWS:

MULTIPLIER	100
CYCLES/SEC DIAL	10
ATTENUATOR	FULL CW
POWER OFF-ON	ON
TRIGGER	INTERNAL

2.5.2 MAIN CHASSIS RESISTANCE AND DC VOLTAGE CHART (CONTINUED)

(B) DC VOLTAGE MEASUREMENTS

(1) THE DC VOLTAGE MEASUREMENTS WERE MADE WITH A VTVM HAVING AN 11 MEGOHM INPUT RESISTANCE. THE INSTRUMENT INPUT VOLTAGE WAS ADJUSTED TO 117 VAC.

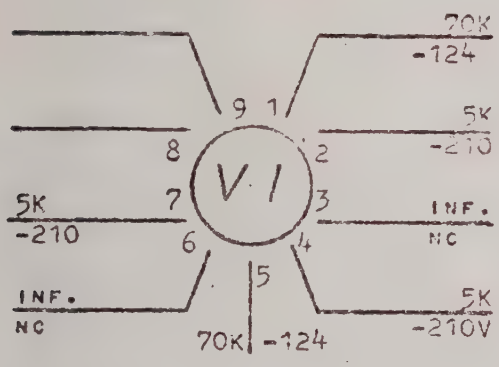
(2) THE FUNCTION GENERATOR CONTROLS WERE SET AS FOLLOWS:

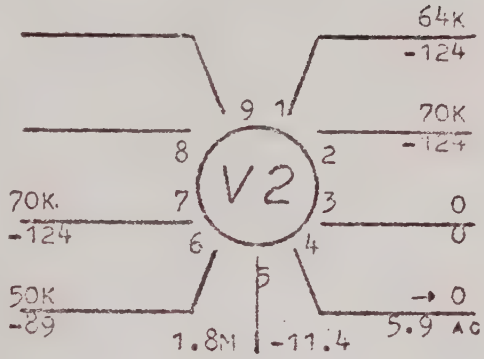
MULTIPLIER	100
CYCLES/SEC DIAL	10
ATTENUATOR	FULL CW
POWER OFF-ON	ON
TRIGGER	INTERNAL

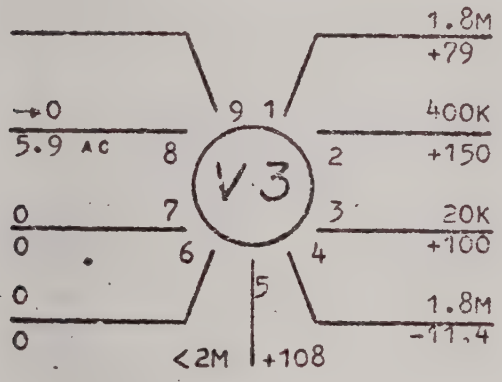
2.6 WAVEFORM AMPLITUDE AND DC LEVEL CHART

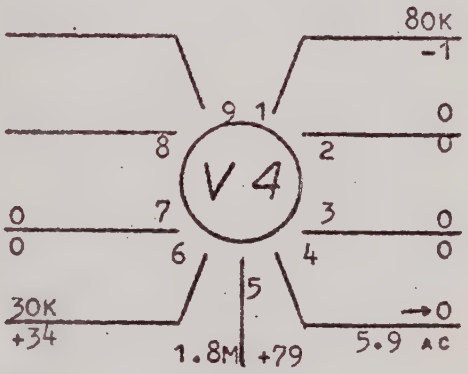
THE WAVEFORM AMPLITUDES AND DC LEVELS WERE MEASURED USING A TEKTRONIX TYPE 532 OSCILLOSCOPE WITH A TYPE CA DUAL TRACE PLUG-IN. THE FUNCTION GENERATOR CONTROLS WERE SET AS LISTED IN PARAGRAPH 2.5.2 (A) AND (B).

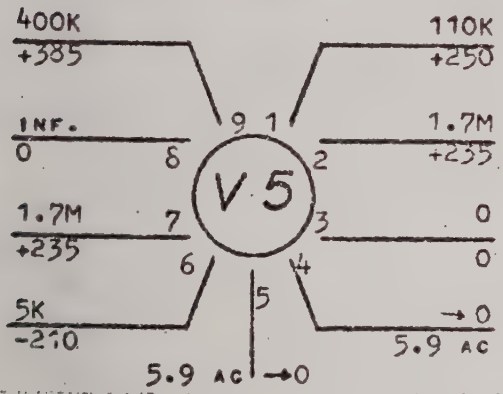
POWER SUPPLY DC VOLTAGE AND RESISTANCE CHART

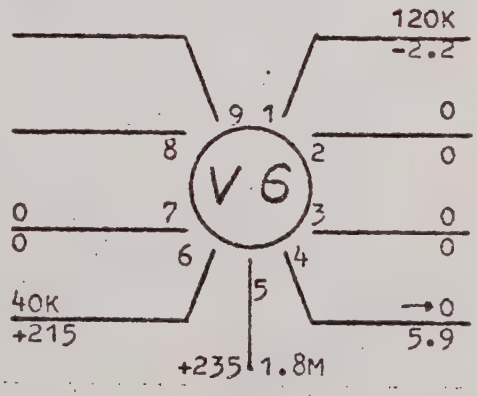


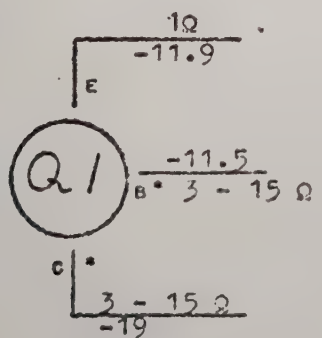


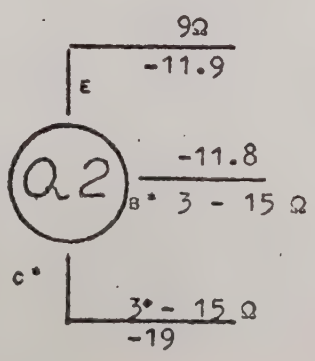






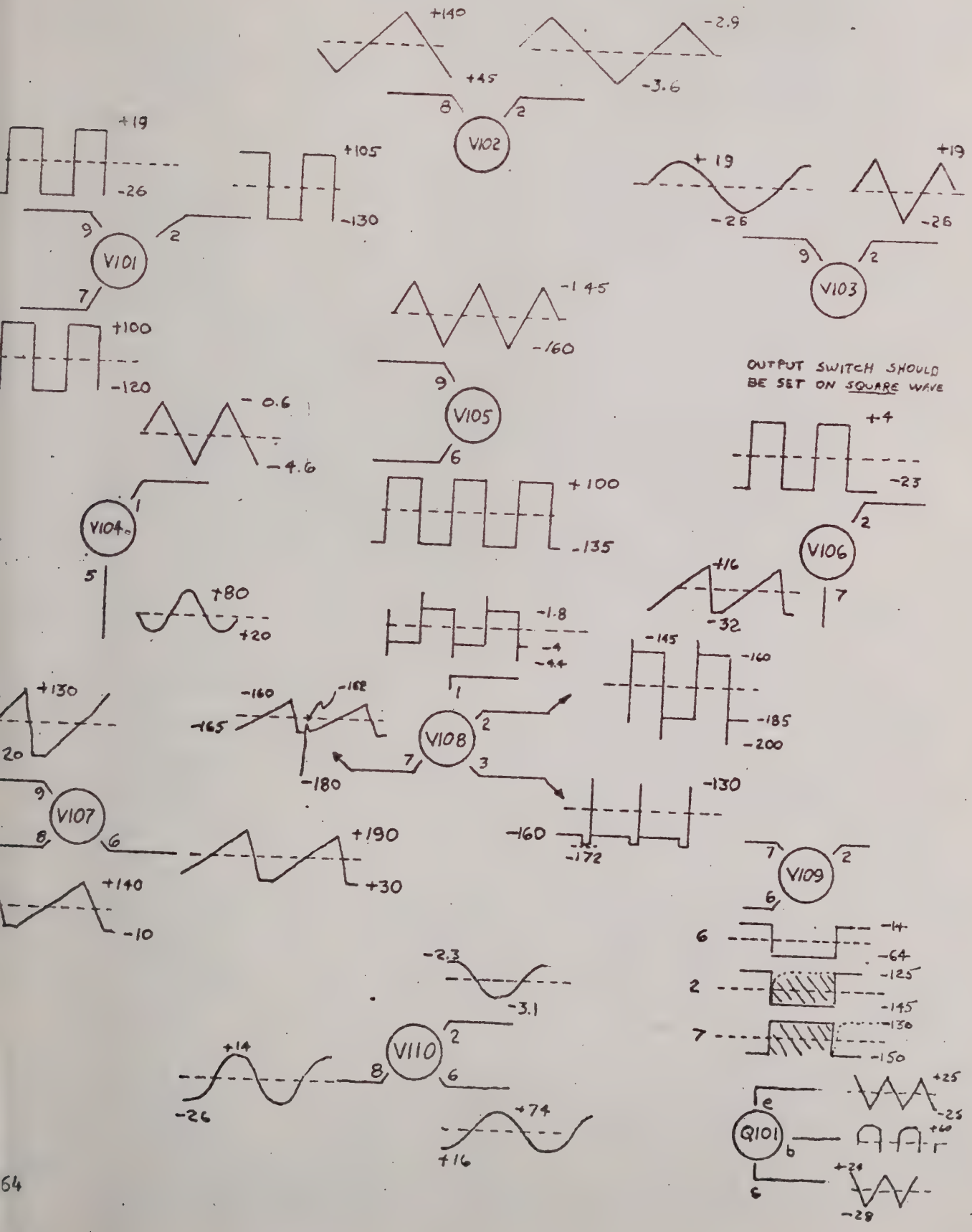






*DEPENDS ON METER POLARITY

MAIN CHASSIS WAVEFORM AMPLITUDE AND DC LEVEL CHART



SECTION III CALIBRATION

3.1 - POWER SUPPLY

3.1.1 PRELIMINARY SETTINGS AND ADJUSTMENTS
3.1.2 POWER SUPPLY RESISTANCE CHECKS
3.1.3 POWER SUPPLY VOLTAGE CHECKS
3.1.4 POWER SUPPLY REGULATION
3.1.5 POWER SUPPLY RIPPLE CHECKS

3.2 - TIMING

3.2.1 PRELIMINARY SETTINGS AND ADJUSTMENTS
3.2.2 TRIANGLE WAVEFORM BALANCE
3.2.3 PRELIMINARY TIMING
3.2.4 SQUARE WAVEFORM SYMMETRY
3.2.5 FINAL TIMING
3.2.6 FINAL FUNCTION GENERATOR TIMING CHECK

3.3 - TRIANGLE WAVEFORM LINEARITY

3.3.1 PRELIMINARY SETTINGS AND ADJUSTMENTS
3.3.2 LINEARITY CHECK (100 CYCLES/SEC)
3.3.3 LINEARITY CHECK (10 CYCLES/SEC)
3.3.4 VERIFICATION OF LINEARITY

3.4 - SINE WAVEFORM CALIBRATION

3.4.1 PRELIMINARY SETTINGS AND ADJUSTMENTS
3.4.2 FINAL SINE WAVEFORM ADJUSTMENTS

3.5 - RAMP WAVEFORM CALIBRATION

3.5.1 PRELIMINARY SETTINGS AND ADJUSTMENTS
3.5.2 RAMP WAVEFORM CALIBRATION

3.6 - COSINE WAVEFORM CALIBRATION

3.6.1 PRELIMINARY SETTINGS AND ADJUSTMENTS
3.6.2 COSINE WAVEFORM BALANCING

3.7 - DC LEVELS AND OUTPUT AMPLITUDE

3.7.1 PRELIMINARY SETTINGS AND ADJUSTMENTS
3.7.2 SINE WAVEFORM DC LEVEL AND AMPLITUDE MEASUREMENT
3.7.3 TRIANGLE WAVEFORM DC LEVEL AND AMPLITUDE
3.7.4 SQUARE WAVEFORM DC LEVEL AND AMPLITUDE
3.7.5 RAMP WAVEFORM DC LEVEL
3.7.6 COSINE WAVEFORM DC LEVEL AND AMPLITUDE

3.8 - INPUT TRIGGER CHECKS

3.8.1 PRELIMINARY SETTINGS AND ADJUSTMENTS
3.8.2 SINGLE SHOT TRIGGER TESTS
3.8.3 EXTERNAL TRIGGER TESTS

-0664

CAUTION COVERS MUST BE IN PLACE DURING FINAL CALIBRATION.

CALIBRATION PROCEDURE

THE FOLLOWING TEST EQUIPMENT OR SUITABLE EQUIVALENTS OF KNOWN ACCURACY ARE REQUIRED FOR COMPLETE CALIBRATION OF THE TYPE 251 FUNCTION GENERATOR.

1.	MULTIMETER	TRIPLET MODEL 630
2.	OSCILLOSCOPE	TEKTRONIX 503
3.	DISTORTION ANALYZER	HEWLETT PACKARD 330B
4.	AUTO TRANSFORMER	GENERAL RADIO TYPE M5

3.1 POWER SUPPLY

3.1.1 PRELIMINARY SETTINGS AND ADJUSTMENTS

(A) PLACE A STRAP BETWEEN THE CHAS GRD AND CKT GRD.

(B) SET THE MULTIPLIER SWITCH TO .001 AND THE CYCLES/SEC DIAL TO X1.

3.1.2 POWER SUPPLY RESISTANCE CHECKS

USING THE MULTIMETER, VERIFY THAT THE POWER SUPPLY RESISTANCES ARE AS SPECIFIED BELOW:

-210 VOLT SUPPLY APPROXIMATELY 5,000Ω
+250 VOLT SUPPLY APPROXIMATELY 60,000Ω MIN.
+100 VOLT SUPPLY APPROXIMATELY 19,000Ω

3.1.3 POWER SUPPLY VOLTAGE CHECKS

(A) CONNECT THE FUNCTION GENERATOR THROUGH THE VARIAC TO 117V, 60CPS.

(B) USING THE MULTIMETER, VERIFY THAT THE POWER SUPPLY VOLTAGES ARE AS SPECIFIED BELOW:

-210 VOLT SUPPLY	-210VDC (ADJUSTABLE)
+100 VOLT SUPPLY	+100 ±5VDC
+250 VOLT SUPPLY	+250 ±13VDC
- 11 VOLT SUPPLY	- 11 ±1.1VDC

3.1.4 POWER SUPPLY REGULATION

VERIFY THAT ALL SUPPLIES REGULATE AS THE INPUT VOLTAGE IS VARIED FROM 105 TO 125 VAC

3.1.5 POWER SUPPLY RIPPLE CHECK

(A) SET THE OSCILLOSCOPE CONTROLS AS FOLLOWS:

VERTICAL SENSITIVITY	MAX.
INPUT COUPLING	AC
SWEEP TIMING	10 MSEC/CM
TRIGGER	CONTINUOUSLY RUNNING

3.1.5 POWER SUPPLY RIPPLE CHECK (CONTINUED)

(B) AT THE FUNCTION GENERATOR REMOVE V105.

(C) USING THE OSCILLOSCOPE, VERIFY THAT RIPPLE VOLTAGES DO NOT EXCEED THE VOLTAGE SPECIFIED FOR EACH SUPPLY LISTED BELOW:

-210 VOLTS	10MV MAX.
+100 VOLTS	10MV MAX.
+250 VOLTS	10MV MAX.
- 11 VOLTS	100MV MAX.

(D) AT THE FUNCTION GENERATOR REPLACE V105.

3.2 TIMING

3.2.1 PRELIMINARY SETTINGS AND ADJUSTMENTS

(A) SET THE FUNCTION GENERATOR CONTROLS AS FOLLOWS:

MULTIPLIER SWITCH	10

(B) CHECK THE CYCLES/SEC DIAL FOR MECHANICAL CENTER AND SET TO X10.

(C) SET THE OSCILLOSCOPE CONTROLS AS FOLLOWS:

VERTICAL SENSITIVITY	1 V/CM
INPUT COUPLING	DC
SWEEP TIMING	10 MSEC/CM
TRIGGER	EXTERNAL

3.2.2 TRIANGLE WAVEFORM BALANCE

THE INSTRUMENT SHOULD BE ON AT LEAST 15 MINUTES BEFORE ANY OF THE FOLLOWING ADJUSTMENTS ARE MADE.

CONNECT THE VERTICAL AMPLIFIER OF THE OSCILLOSCOPE TO PIN #8 OF V102 AND ADJUST THE MILLER DC BAL R188 UNTIL THE BOTTOM OF THE TRIANGLE WAVEFORM IS AT +52 ±2V. THE AMPLITUDE OF THE WAVEFORM AT THIS LEVEL WILL VARY SLIGHTLY FROM INSTRUMENT TO INSTRUMENT. HOWEVER THE MOST IMPORTANT SETTING IS TO HAVE THE NEGATIVE PEAK OF THE TRIANGLE WAVEFORM AT +52 ±2V.

3.2.3 PRELIMINARY TIMING

(A) CONNECT THE VERTICAL AMPLIFIER OF THE OSCILLOSCOPE TO THE TRIANGLE WAVEFORM OUTPUT TERMINAL. SET THE VERTICAL SENSITIVITY TO 10 V/CM.

3.2.3 PRELIMINARY TIMING (CONTINUED)

(B) CONNECT THE TRIGGER INPUT OF THE OSCILLOSCOPE TO THE FUNCTION GENERATOR EXT TRIG OUT.

(C) ADJUST THE MAIN TIMING ADJ R161 AND VERIFY THAT TEN TRIANGLE WAVEFORMS APPEAR FOR 10 CM OF SWEEP ON THE OSCILLOSCOPE.

3.2.4 SQUARE WAVEFORM SYMMETRY

(A) SET THE OSCILLOSCOPE CONTROLS AS FOLLOWS:

VERTICAL SENSITIVITY	10 V/CM
INPUT COUPLING	DC
SWEEP TIMING	1 MSEC/CM
TRIGGER	INTERNAL

(B) CONNECT THE VERTICAL AMPLIFIER OF THE OSCILLOSCOPE TO THE SQUARE WAVEFORM OUTPUT TERMINAL OF THE FUNCTION GENERATOR. ADJUST THE OSCILLOSCOPE TRIGGERING SO THAT A CHANGE FROM PLUS TO MINUS INTERNAL TRIGGERING WILL CAUSE A STATIONARY POLARITY REVERSAL OF ONE CYCLE OF THE SQUARE WAVEFORM.

(C) POSITION THE RISE OR FALL OF THE SQUARE WAVEFORM TO THE CENTER OF THE GRATICULE AND TURN THE OSCILLOSCOPE MAGNIFIER TO ON.

(D) WHILE SWITCHING THE OSCILLOSCOPE TRIGGER BETWEEN PLUS AND MINUS INTERNAL TRIGGERING, ADJUST THE SQUARE SYMMETRY (X10) R173 FOR NO SHIFT IN THE WAVEFORM: (EQUAL POSITIVE AND NEGATIVE PORTIONS REFERENCED TO TIME).

(E) SET THE FUNCTION GENERATOR CYCLES/SEC DIAL TO X1, THE MULTIPLIER TO 100 AND THE OSCILLOSCOPE SWEEP TO 1 MSEC/CM.

(F) REPEAT THE PROCEDURE IN 3.2.4 (D) ADJUSTING THE SQUARE SYMMETRY (X1) R177 FOR NO SHIFT IN THE WAVEFORM.

3.2.5 FINAL TIMING

(A) SET THE FUNCTION GENERATOR CONTROLS AS FOLLOWS:

MULTIPLIER	10
CYCLES/SEC DIAL	10

(B) SET THE OSCILLOSCOPE CONTROLS AS FOLLOWS;

VERTICAL SENSITIVITY	10 V/CM
INPUT COUPLING	DC
SWEEP TIMING	10 MSEC/CM
TRIGGER	EXTERNAL (NEGATIVE)
MAGNIFIER	OFF

3.2.6 FINAL FUNCTION GENERATOR TIMING CHECK

(A) (CONTINUED)

(3) SET THE OSCILLOSCOPE SWEEP TIMING TO 100μSEC/CM, THE FUNCTION GENERATOR MULTIPLIER SWITCH TO 1000, AND THE CYCLES/SEC DIAL TO X1.

(4) VERIFY THAT THE FUNCTION GENERATOR IS CORRECTLY TIMED AT 1000 CYCLES PER SECOND BY OBSERVING ONE CYCLE OF THE TRIANGLE WAVEFORM FOR 10 CM OF SWEEP ON THE OSCILLOSCOPE.

(B) MID FREQUENCY TIMING CHECK

(1) SET THE OSCILLOSCOPE SWEEP TIMING TO 100μSEC/CM, THE FUNCTION GENERATOR MULTIPLIER SWITCH TO 100 AND THE CYCLES/SEC DIAL TO X10.

(2) VERIFY THAT THE FUNCTION GENERATOR IS CORRECTLY TIMED AT 1000 CYCLES PER SECOND BY OBSERVING ONE CYCLE OF THE TRIANGLE WAVEFORM FOR 10 CM OF SWEEP ON THE OSCILLOSCOPE.

(3) SET THE OSCILLOSCOPE SWEEP TIMING TO 1 MSEC/CM, THE FUNCTION GENERATOR MULTIPLIER SWITCH TO 100 AND THE CYCLES/SEC DIAL TO X1.

(4) VERIFY THAT THE FUNCTION GENERATOR IS CORRECTLY TIMED AT 100 CYCLES PER SECOND BY OBSERVING ONE CYCLE OF THE TRIANGLE WAVEFORM FOR 10 CM OF SWEEP ON THE OSCILLOSCOPE.

(C) LOW FREQUENCY TIMING CHECK

(1) SET THE OSCILLOSCOPE SWEEP TIMING TO 10 MSEC/CM, THE FUNCTION GENERATOR MULTIPLIER SWITCH TO 1 AND THE CYCLES/SEC DIAL TO X10.

(2) VERIFY THAT THE FUNCTION GENERATOR IS CORRECTLY TIMED AT 10 CYCLES PER SECOND BY OBSERVING ONE CYCLE OF THE TRIANGLE WAVEFORM FOR 10 CM OF SWEEP ON THE OSCILLOSCOPE.

(3) SET THE OSCILLOSCOPE SWEEP TIMING TO 100 MSEC/CM, THE FUNCTION GENERATOR MULTIPLIER SWITCH TO 1 AND THE CYCLES/SEC DIAL TO X1.

(4) VERIFY THAT THE FUNCTION GENERATOR IS CORRECTLY TIMED AT 1 CYCLE PER SECOND BY OBSERVING ONE CYCLE OF THE TRIANGLE WAVEFORM FOR 10 CM OF SWEEP ON THE OSCILLOSCOPE.

(D) REPEAT STEPS 3.2.6 (C) 1 THROUGH 4 FOR FREQUENCIES .1, .01 AND .001.

3.3 TRIANGLE LINEARITY

NOTE: IN THIS CHECK IT IS VERY IMPORTANT THAT AN OSCILLOSCOPE WHOSE CRT GEOMETRY AND LINEARITY ARE CALIBRATED TO 1/2%, OR BETTER, BE USED. (CHECK THE OSCILLOSCOPE LINEARITY BY OBSERVING THE OSCILLOSCOPE'S SAWTOOTH OUT.)

3.3.1 PRELIMINARY SETTINGS AND ADJUSTMENTS

(A) SET THE OSCILLOSCOPE CONTROLS AS FOLLOWS:

VERTICAL SENSITIVITY	10 V/CM
SWEEP TIMING	0.5 MSEC/CM
INPUT COUPLING	DC
TRIGGER	EXTERNAL (NEGATIVE)

(B) SET THE FUNCTION GENERATOR CONTROLS AS FOLLOWS:

MULTIPLIER	10
CYCLES/SEC DIAL	10

3.3.2 LINEARITY CHECK (100 CYCLES/SEC)

(A) CONNECT THE VERTICAL AMPLIFIER OF THE OSCILLOSCOPE TO THE TRIANGLE WAVEFORM OUTPUT TERMINAL OF THE FUNCTION GENERATOR.

(B) ADJUST THE VERTICAL GAIN AND THE SWEEP VERNIER OF THE OSCILLOSCOPE TO DISPLAY ONLY THE RISING HALF CYCLE OF THE TRIANGLE WAVEFORM OVER THE ENTIRE GRATICULE AREA.

(C) OBSERVE THE LINEARITY OF THE WAVEFORM.

(D) SET THE OSCILLOSCOPE TRIGGERING TO EXTERNAL (POSITIVE).

(E) OBSERVE THE LINEARITY OF THE FALLING HALF CYCLE OF THE TRIANGLE WAVEFORM OCCUPYING THE ENTIRE GRATICULE AREA.

3.3.3 LINEARITY CHECK (10 CYCLES/SEC)

(A) SET THE OSCILLOSCOPE SWEEP TIMING TO 5.0 MSEC/CM AND THE FUNCTION GENERATOR CYCLES/SEC DIAL TO X1.

(B) REPEAT PARAGRAPH 3.3.2 (A) THROUGH (E) AT THE X1 END OF THE CYCLES/SEC DIAL.

NOTE: VERIFY THAT THE NON-LINEARITY IS LESS THAN 1% THROUGHOUT THE TESTS IN PARAGRAPHS 3.3.2 (A) THROUGH 3.3.3 (B). IF EXCEEDING 1%, TRY CHANGING V102 AND REPEAT CALIBRATION PARAGRAPHS 3.2.1 THROUGH 3.2.5.

3.4 SINE WAVEFORM CALIBRATION

NOTE: A SINE WAVEFORM WITH MINIMUM DISTORTION IS DEPENDENT UPON THE ACCURACY OF THE PROCEEDING ADJUSTMENTS AS WELL AS THE FOLLOWING SINE SHAPE ADJUSTMENTS. ANY SUBSEQUENT CHANGES OR RECALIBRATION OF PREVIOUS STEPS WILL MAKE IT NECESSARY THAT SINE CALIBRATION BE RECHECKED.

3.4.1 PRELIMINARY SETTINGS AND ADJUSTMENTS

(A) SET THE OSCILLOSCOPE CONTROLS AS FOLLOWS:

VERTICAL SENSITIVITY	10 V/CM
SWEEP TIMING	2 TO 5 MSEC/CM
INPUT COUPLING	DC
TRIGGER	EXTERNAL

(B) SET THE CONTROLS OF THE FUNCTION GENERATOR AS FOLLOWS:

MULTIPLIER	10
CYCLES/SEC DIAL	10

(C) CONNECT THE VERTICAL AMPLIFIER OF THE OSCILLOSCOPE TO THE SINE WAVEFORM OUTPUT TERMINAL OF THE FUNCTION GENERATOR.

(D) SHAPE THE SINE WAVEFORM AS FOLLOWS:

(1) ADJUST C SINE SHAPE R202 FULLY CCW (GROUND).

(2) USING FIGURES 1 THROUGH 5 WITH THEIR RESPECTIVE NOTES, ADJUST A SINE SHAPE AND C SINE SHAPE (R185 AND R193) FOR THE BEST SINE WAVEFORM POSSIBLE.

NOTE: THESE ADJUSTMENTS ARE VERY INTERDEPENDENT. ONE CAN BE AT A SETTING WHERE IT IS IMPOSSIBLE FOR THE OTHER TO CORRECT. B SINE SHAPE CONTROLS MORE OF THE AMPLITUDE AND A SINE SHAPE CONTROLS MORE OF THE SHAPE ITSELF. IT IS BEST TO SET B FOR NEARLY MAXIMUM AMPLITUDE, THEN AS A IS ADJUSTED B CAN BE REDUCED IN AMPLITUDE TO MAINTAIN PROPER SHAPE. THIS IS AN OPTIMUM WAVE SHAPE AT THIS POINT.

(3) ADJUST C SINE SHAPE TO ROUND THE BOTTOM OF THE SINE WAVEFORM. A AND B SINE SHAPES MAY BE READJUSTED FOR FINAL SMOOTHING.

3.4.2 FINAL SINE WAVE ADJUSTMENTS

(A) CONNECT THE DISTORTION ANALYZER INPUT TO THE SINE WAVEFORM OUTPUT TERMINAL OF THE FUNCTION GENERATOR.

(B) CAREFULLY ADJUST A, B AND C SINE SHAPES FOR MINIMUM HARMONIC DISTORTION.

3.4.2 FINAL SINE WAVEFORM ADJUSTMENTS (CONTINUED)

(D) VERIFY THAT THE TOTAL HARMONIC DISTORTION AT 1KC IS LESS THAN 1%.

(E) VERIFY THAT THE TOTAL HARMONIC DISTORTION AT 10KC IS LESS THAN 2%.

NOTE 1: IF THE ABOVE SPECIFICATION CANNOT BE MET, CHANGING OF V104 AND REPEATING CALIBRATION PARAGRAPH 3.4.1 THROUGH 3.4.2 (C) SHOULD BE ACCOMPLISHED.

NOTE 2: IF A WAVEFORM ANALYZER IS USED IN PLACE OF A DISTORTION ANALYZER, THE FIRST 10 HARMONICS SHOULD BE CHECKED WITH ADJUSTMENTS MADE CONSIDERING THE FIRST 5 HARMONICS.

3.5 RAMP WAVEFORM CALIBRATION

3.5.1 PRELIMINARY SETTINGS AND ADJUSTMENTS

(A) SET THE OSCILLOSCOPE CONTROLS AS FOLLOWS:

VERTICAL SENSITIVITY	APPROX. 10 V/CM
SWEEP TIMING	1 MSEC/CM
INPUT COUPLING	DC
TRIGGER	EXTERNAL

(B) SET THE FUNCTION GENERATOR CONTROLS AS FOLLOWS:

MULTIPLIER	100
CYCLES/SEC DIAL	10
TRIGGER SOURCE	INTERNAL
OUTPUT ATTEN	FULL CW

3.5.2 RAMP WAVEFORM CALIBRATION

(A) WITH THE TEST OSCILLOSCOPE ON THE RAMP OUTPUT, ROUGH ADJUST RAMP LENGTH R123 AND RAMP DC LEVEL R121 FOR A STABLE PATTERN DC BALANCED AROUND GROUND. FINE ADJUST RAMP LENGTH R123 FOR A "HOLD-OFF" TIME OF ABOUT 10% AT THE END OF EACH RAMP WAVEFORM. THIS IS NORMAL AND IT IS THERE TO ALLOW THE RAMP WAVEFORM TO FALL AND RE-ESTABLISH DC LEVEL BEFORE RISING AGAIN AND TO ASSURE POSITIVE SYNCHRONIZATION TO THE SQUARE WAVEFORM GENERATOR.

(B) SET THE FUNCTION GENERATOR MULTIPLIER TO 1000 AND OSCILLOSCOPE SWEEP TIME TO 100 µSEC/CM.

(C) ADJUST TIMING CAPACITOR C105A FOR 10 CYCLES IN 20 CM. (NOTE START OF RAMP WAVEFORM AND READJUST IF NOT LINEAR.)

3.5.2 RAMP WAVEFORM CALIBRATION (CONTINUED)

(D) CHANGE FUNCTION GENERATOR CYCLES/SEC DIAL TO X1 AND OSCILLOSCOPE SWEEP TIME TO 1 MSEC/CM.

(E) VERIFY THAT THE "HOLD-OFF" TIME IS NO MORE THAN 10% OF TOTAL PERIOD.

NOTE: AT X1 END OF THE RAMP WAVEFORM TIMING POTENTIOMETER R111B, THE VALUE OF THE GROUND RETURN RESISTOR R110 IS A NOMINAL VALUE AND IS CHOSEN FOR MAINTAINING CORRECT "HOLD-OFF" AT THIS POINT.

3.6 COSINE WAVEFORM CALIBRATION

NOTE: CORRECT COSINE WAVEFORM CALIBRATION DEPENDS ON A CORRECTLY SHAPED SINE WAVEFORM BEING APPLIED AT V110A. INSURE THAT THE SINE WAVEFORM GENERATOR IS OPERATING CORRECTLY BEFORE ATTEMPTING THE FOLLOWING:

3.6.1 PRELIMINARY SETTINGS AND ADJUSTMENTS

(A) SET THE OSCILLOSCOPE CONTROLS AS FOLLOWS:

VERTICAL SENSITIVITY	10 V/CM
SWEEP TIMING	100 TO 300 µSEC/CM
INPUT COUPLING	DC
TRIGGER	EXTERNAL

(B) SET THE FUNCTION GENERATOR CONTROLS AS FOLLOWS:

MULTIPLIER	10
CYCLES/SEC DIAL	10
OUTPUT ATTEN	FULL CW
TRIGGER	INTERNAL

3.6.2 COSINE WAVEFORM BALANCING

(A) CONNECT THE VERTICAL AMPLIFIER OF THE OSCILLOSCOPE TO THE AUXILIARY COSINE WAVEFORM OUTPUT TERMINAL.

(B) ADJUST COSINE X10 BAL (R208) FOR A NON-DISTORTED WAVEFORM BALANCED BETWEEN THE POSITIVE AND NEGATIVE CLIPPING LEVELS.

(C) CHANGE FUNCTION GENERATOR CYCLES/SEC DIAL TO X1 AND OSCILLOSCOPE SWEEP TIME TO APPROXIMATELY TEN TIMES SLOWER THAN USED IN PARA. 3.6.1 (A).

(D) ADJUST COSINE X1 BAL (R221) FOR A NON-DISTORTED WAVEFORM BALANCED BETWEEN THE POSITIVE AND NEGATIVE CLIPPING LEVELS.

(E) REPEAT (A) THROUGH (D) UNTIL THERE IS NO NOTICEABLE DC SHIFT AS THE CYCLES/SEC DIAL IS ROTATED THROUGHOUT ITS RANGE.

3.6.2 COSINE WAVEFORM BALANCING (CONTINUED)

(F) CHANGE FUNCTION GENERATOR CYCLES/SEC DIAL TO X10 AND MULTIPLIER TO 1000. CHANGE OSCILLOSCOPE SWEEP TIME TO APPROXIMATELY .1 MSEC/CM.

(G) ADJUST COSINE X1000 BAL FOR A NON-DISTORTED WAVEFORM BALANCED BETWEEN THE POSITIVE AND NEGATIVE CLIPPING LEVELS.

3.7 DC LEVELS AND OUTPUT AMPLITUDE

3.7.1 PRELIMINARY SETTINGS AND ADJUSTMENTS

(A) SET THE OSCILLOSCOPE CONTROLS AS FOLLOWS:

VERTICAL SENSITIVITY	APPROX. 5 V/CM
SWEEP TIMING	10 MSEC/CM
INPUT COUPLING	DC
TRIGGER	EXTERNAL

(B) SET THE FUNCTION GENERATOR CONTROLS AS FOLLOWS:

MULTIPLIER	10
CYCLES/SEC DIAL	10

(C) CALIBRATE THE OSCILLOSCOPE AS FOLLOWS:

(1) CONNECT THE VERTICAL AMPLIFIER OF THE OSCILLOSCOPE TO A CALIBRATED SIGNAL SOURCE (BUILT-IN OSCILLOSCOPE CALIBRATOR).

(2) SET THE CALIBRATOR OUTPUT FOR 10 VPP.

(3) ADJUST THE VERTICAL GAIN OF THE OSCILLOSCOPE, CALIBRATE THE OSCILLOSCOPE SO THAT 40 VPP IS EQUAL TO 4 CM DEFLECTION.

( ) GROUND THE INPUT OF THE VERTICAL AMPLIFIER AND USING THE VERTICAL POSITIONING CONTROL OF THE OSCILLOSCOPE SET THE SWEEP EXACTLY ON THE VERTICAL CENTERLINE OF THE GRATICULE.

NOTE: THE OSCILLOSCOPE IS NOW CALIBRATED TO DISPLAY A WAVEFORM OF 40 VPP/4CM WITH THE DC GROUND CONTROL ON THE CENTER OF THE GRATICULE.

DO NOT TOUCH THE VERTICAL CONTROLS OF THE OSCILLOSCOPE DURING THE FOLLOWING PROCEDURE.

(D) AT THE FUNCTION GENERATOR, ADJUST THE ATTENUATOR TO FULL CCW AND CONNECT THE MULTIMETER BETWEEN GROUND AND THE MAIN OUTPUT.

(E) ADJUST THE MIN AMP DC BAL R134 FOR 0 VOLTS AD INDICATED BY THE MULTIMETER. REMOVE METER.

3.7.2 SINE WAVEFORM DC LEVEL AND AMPLITUDE MEASUREMENT

(A) CONNECT THE VERTICAL AMPLIFIER OF THE OSCILLOSCOPE TO THE MAIN OUTPUT TERMINAL OF THE FUNCTION GENERATOR.

(B) SET THE FUNCTION GENERATOR ATTENUATOR TO FULL CW.

(C) WITH THE OUTPUT SELECTOR SWITCH SET TO SINE, ACCURATELY MEASURE AND RECORD THE PP AMPLITUDE OF THE SINE WAVEFORM.

(D) CONNECT THE MULTIMETER BETWEEN THE MAIN OUTPUT AND GROUND. THE MULTIMETER SHOULD BE SET ON THE 10 VDC SCALE.

(E) ADJUST SINE DC LEVEL R216 FOR ZERO INDICATION ON METER. INCREASE METER SENSITIVITY AS NEEDED.

NOTE: THE SINE DC LEVEL WILL REQUIRE READJUSTMENT AFTER ADJUSTMENT OF THE COSINE DC LEVEL. SEE PARA. 3.7.5 (E).

3.7.3 TRIANGLE WAVEFORM DC LEVEL AND AMPLITUDE

(A) REPEAT PARA. 3.7.2 (A) AND (B).

(B) WITH THE OUTPUT SELECTOR SWITCH SET TO TRIANGLE AND USING TRIANGLE AMP ADJ R205, SET THE TRIANGLE WAVEFORM AMPLITUDE EQUAL TO THAT OF THE SINE WAVEFORM.

(C) CONNECT THE MULTIMETER BETWEEN THE MAIN OUTPUT AND GROUND. THE MULTIMETER SHOULD BE SET ON THE 10 VDC SCALE.

(D) ADJUST TRIANGLE DC LEVEL R191 FOR ZERO INDICATION ON THE METER. INCREASE METER SENSITIVITY AS NEEDED.

3.7.4 SQUARE WAVEFORM DC LEVEL AND AMPLITUDE

(A) REPEAT PARA. 3.7.2 (A) AND (B).

(B) WITH THE OUTPUT SELECTOR SWITCH SET TO SQUARE AND USING SQUARE AMP. ADJ. R165, SET THE SQUARE AMPLITUDE EQUAL TO THAT OF THE SINE WAVEFORM.

(C) CONNECT THE MULTIMETER BETWEEN THE MAIN OUTPUT AND GROUND.. THE MULTIMETER SHOULD BE SET ON THE 10 VDC SCALE.

(D) ADJUST SQUARE DC LEVEL R167 FOR ZERO INDICATION ON THE METER. INCREASE METER SENSITIVITY AS NEEDED.

3.7.5 RAMP WAVEFORM DC LEVEL

(A) REPEAT PARA. 3.7.2 (A) AND (B).

3.7.5 RAMP WAVEFORM DC LEVEL (CONTINUED)

(B) WITH THE OUTPUT SELECTOR SWITCH SET TO RAMP AND USING RAMP DC LEVEL R121, ADJUST RAMP WAVEFORM TO CENTER ABOUT 0 DC REFERENCE (EQUAL DISPLACEMENT ABOVE AND BELOW 0 DC REFERENCE.

3.7.6 COSINE WAVEFORM DC LEVEL AND AMPLITUDE

(A) REPEAT PARA. 3.7.2 (A) AND (B).

(B) WITH THE OUTPUT SELECTOR SWITCH SET TO COSINE, CHECK THE AMPLITUDE OF THE COSINE WAVEFORM AT 100 CYCLES, 1000 CYCLES AND 10KC. ADJUST COS AMPL (C123A) AT 10KC TO MATCH THE AMPLITUDE AT LOWER FREQUENCIES.

(C) CONNECT THE MULTIMETER BETWEEN THE MAIN OUTPUT AND GROUND. THE MULTIMETER SHOULD BE SET ON THE 10VDC SCALE.

(D) ADJUST COSINE DC LEVEL (R215) FOR ZERO INDICATION ON THE METER. INCREASE METER SENSITIVITY AS NEEDED.

(E) REPEAT PARA. 3.7.2 (D) AND (E).

3.8. INPUT TRIGGER CHECKS

3.8.1 PRELIMINARY SETTINGS AND ADJUSTMENTS

(A) SET THE OSCILLOSCOPE CONTROLS AS FOLLOWS:

VERTICAL SENSITIVITY	10 V/CM
SWEEP TIMING	.5 MSEC/CM
INPUT COUPLING	DC
TRIGGER	EXTERNAL

(B) SET THE FUNCTION GENERATOR CONTROLS AS FOLLOWS:

MULTIPLIER	1000
CYCLES/SEC DIAL	10
OUTPUT	TRIANGLE
TRIGGER	EXTERNAL

3.8.2 SINGLE SHOT TRIGGER TESTS

(A) CONNECT THE VERTICAL AMPLIFIER OF THE OSCILLOSCOPE TO THE MAIN OUTPUT TERMINAL OF THE FUNCTION GENERATOR.

(B) PRESS THE MANUAL TRIGGER PUSHBUTTON AND OBSERVE THE WAVEFORM ON THE OSCILLOSCOPE. ADJUST HOLD OFF DC LEVEL (R213) UNTIL THE GENERATED WAVEFORM STARTS AND STOPS AT ZERO DC REFERENCE.

(C) VERIFY THAT A SINGLE WAVEFORM IS GENERATED FOR EACH APPLIED MANUAL TRIGGER.

3.8.2 SINGLE SHOT TRIGGER TESTS (CONTINUED)

(D) REPEAT (A) THROUGH (C) ABOVE FOR EACH POSITION OF THE OUTPUT SELECTOR SWITCH. THE COSINE WAVEFORM WILL REQUIRE ADDITIONAL ADJUSTMENT OF THE HOLD OFF DC LEVEL (R213). SEE FIGS. 6 AND 7.

3.8.3 EXTERNAL TRIGGER TESTS

(A) CONNECT THE EXTERNAL TRIGGER TERMINAL OF THE FUNCTION GENERATOR TO AN EXTERNAL TRIGGER SOURCE OF AT LEAST 15V WITH A FREQUENCY OF APPROXIMATELY 1KC (I.E. OSCILLOSCOPE CALIBRATOR OUT) AND OBSERVE THE WAVEFORM ON THE OSCILLOSCOPE.

(B) VERIFY THAT THE OUTPUT WAVEFORM IS TRIGGERED AT A REPETITION RATE EQUAL TO THAT OF THE TRIGGER SOURCE.

(C) REPEAT (A) AND (B) ABOVE FOR EACH POSITION OF THE OUTPUT SELECTOR SWITCH. AGAIN THE HOLD-OFF DC LEVEL (R213) MAY REQUIRE READJUSTMENT FOR CORRECT COSINE WAVEFORM GENERATION START AND STOP (SEE FIG. 8).

FIGURE 1

SINE ADJ B ABOUT CORRECT, BUT SINE ADJ A TOO FAR CW. ROTATE "A" CCW UNTIL BOTTOM IS LESS FLAT AND TOP MORE FULL AND ROUND.

FIGURE 2

SINE ADJ B TOO FAR CCW. ROTATE CW UNTIL TOP IS PROPER SHAPE. IF BOTH TOP AND BOTTOM ARE FLAT, REDUCE AMPLITUDE WITH SINE ADJ B (CW ROTATION) AND ADJUST "A" TO RE-CENTER WAVEFORM (SYMMETRICAL SHAPE).

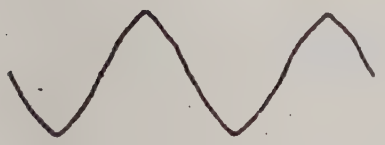


FIGURE 3

NOT ENOUGH ADJUSTMENT OF EITHER "A" OR "B". INCREASE AMPLITUDE (CW) WITH SINE ADJ B AND ADJUST "A" CW TO RE-CENTER WAVEFORM.

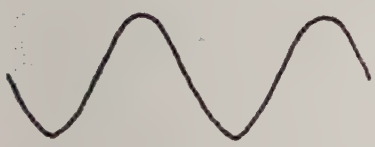


FIGURE 4

APPROXIMATELY OPTIMUM SETTING OF "A" AND "B" AND NOW AN ADJUSTMENT OF SINE ADJ C WILL ROUND THE BOTTOM OF THE WAVEFORM PROPERLY.

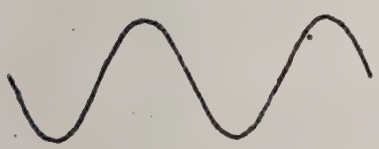
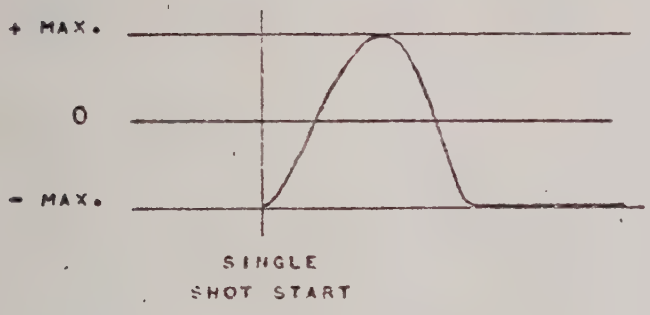


FIGURE 5

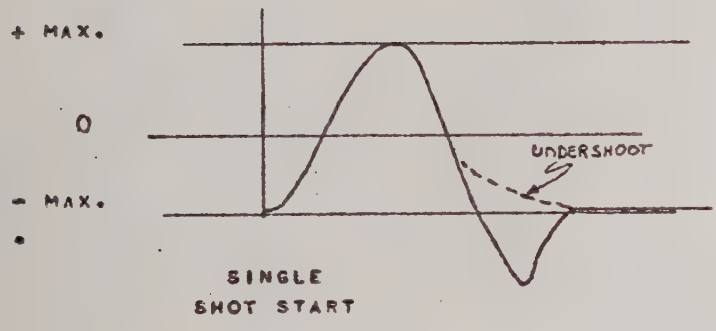
SINE ADJ C MADE PROPERLY. OPTIMUM SINE WAVEFORM.

THE "B" ADJUSTMENT ADDS SIGNAL TO THE SHAPING CIRCUIT; CCW ROTATION CAUSES FLATTENING, CW ROTATION CAUSES THE SINE WAVE TO APPROACH A TRIANGLE WAVE. "A" ADJUSTMENT CONTROLS DC LEVEL AND RE-CENTERS THE WAVEFORM. "C" ADJUSTMENT SERVES TO SHAPE ONLY THE BOTTOM OF THE WAVEFORM.



CORRECT COSINE WAVE DURING MANUAL TRIGGER (SINGLE SHOT) OPERATION.

FIGURE 6



COSINE WAVE SHOWING OVERSHOOT (UNDERSHOOT) DUE TO IMPROPER ADJUSTMENT OF HOLDOFF DC LEVEL R151.

FIGURE 7

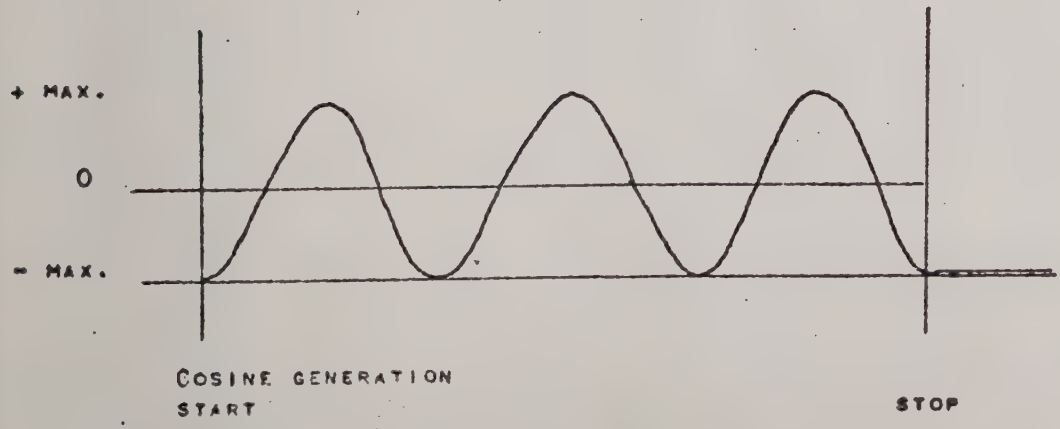


FIGURE 8

SECTION IV

PARTS LIST

ABBREVIATIONS USED IN OUR PARTS LIST

CER.	CERAMIC	μμ	MICROMICRO
COMP	COMPOSITION	M	MILLI
EMC	ELECTROLYTIC, METAL CASED	PREC	PRECISION
EMT	ELECTROLYTIC, METAL TUBULAR	PT	PAPER TUBULAR
FD	FARAD	TUB.	TUBULAR
H	HENRY	V	WORKING VOLTS DC
K	THOUSANDS OF OHMS	VAR	VARIABLE
MEG	MEGOHMS	W	WATT
MF	METAL FILM	WW	WIRE WOUND
μ	MICRO	PF	PICO FARAD

THE COLUMN PRECEDING THE PARTS NUMBERS CONTAINS THE ABBREVIATIONS OF THE MANUFACTURERS FROM WHOM WE PURCHASE THE SPECIFIED PART. THESE ABBREVIATIONS ARE LISTED BELOW.

AB	ALLEN BRADLEY
AMX	AMPEREX
BB	BIRNBACH
BNS	BOURNS
CD	CONTINENTAL DEVICE CORP.
CL	CLAROSTAT
CLR	CENTRALAB
CNG	CORNING RESISTOR
CR	CLARO RESISTOR
CW	CONTINENTAL-WIRT
DE	DELCO
DI	DIODES INC.
ER	ERIE TECHNOLOGICAL PRODUCTS
EX	EXACT ELECTRONICS INC.
GE	GENERAL ELECTRIC CO.
GR	GRAYHILL
IRC	INTERNATIONAL RESISTANCE CORP.
LF	LITTLEFUSE
MA	MALLORY
MTR	MOTOROLA
OAK	OAK ELECTRONICS CORP.
PEN	PENN RESISTOR CORP.
RCA	RADIO CORP. OF AMERICA
RMC	RADIO MATERIALS CO.
SG	SIGNALITE
SPR	SPRAGUE ELECTRIC
SPE	SPECTROL
SR	SARTRON INC.
ST	SARKES TARZIAN INC.
TI	TEXAS INSTRUMENTS
TJ	TOBIAS JENSEN
TS	TUNG-SOL
WH	WESTINGHOUSE
WL	WARD LEONARD

BULBS

B1	#12	6 v		GE	150018

CAPACITORS

C1	80 ufd	500 v	EMC		SPR	290028
C2 A&B	20/20 ufd	450 v	EMC		SPR	290009
C3	80 ufd	500 v	EMC		SPR	290028
C4 A&B	20/20 ufd	450 v	EMC		SPR	290009
C5 A&B	20/20 ufd	450 v	EMC		SPR	290009
C6	.01 ufd	400 v		10%	AMX	285203
C7	.01 ufd	400 v		10%	AMX	285203
C8	.01 ufd	400 v		10%	AMX	285203
C9	2000 ufd	20 v	EMC		SPR	290029

DIODES

D1-D12	IN3194	RCA	152016
D13-D16	IN1217	WH	152005
D17	ZA12B Zener	MA	152022

FUSES

F1	2A 3AG	LF	159020

RESISTORS

R1	120 K	1/2W	Fixed	Comp.	10%	AB	302124
R2	1 M	1/2W	Fixed	Comp.	10%	AB	302105
R3	100 K	1/2W	Fixed	Comp.	10%	AB	302104
R4	1.5 M	1/2W	Fixed	Comp.	10%	AB	302155
R5	10 ohm	1W	Fixed	Comp.	10%	AB	304100
R6	39 K	1/2W	Fixed	Comp.	10%	AB	302393
R7	680 K	1/2W	Fixed	Comp.	10%	AB	302684
R8	100 K	1/2W	Fixed	Comp.	10%	AB	302104
R9	1.5 M	1/2W	Fixed	Comp.	10%	AB	302155
R10	10 ohm	1/2W	Fixed	Comp.	10%	AB	302100
R11	10 ohm	1/2W	Fixed	Comp.	10%	AB	302100
R12	390 K	1/2W	Fixed	Comp.	10%	AB	302394
R13	47 K	1/2W	Fixed	Comp.	10%	AB	302473
R14	330 K	1/2W	Fixed	Comp.	10%	AB	302334
R15	1.5 M	1/2W	Fixed	Comp.	10%	AB	302155
R16	68 K	1W	Fixed	Comp.	10%	AB	304683
R17	200 K	1/2W	Fixed	Prec.	1%	CR	309051
R18	165 K	1/2W	Fixed	Prec.	1%	CR	309050
R19	100 K	1/2W	Fixed	Prec.	1%	CR	309045
R20	210 K	1/2W	Fixed	Prec.	1%	CR	309126
R21	150 K	1/2W	Fixed	Prec.	1%	CR	309049
R22	100 K	1/2W	Fixed	Prec.	1%	CR	309045
R23	15 K	5W	VAR.	WW -210 v ADJUST		CTS	311013

RESISTORS (cont.)

P24							
R25							
R26							
R27	25 ohm	5W	Fixed	WW	5%	SPR	308026
R28	820 ohm	1/2W	Fixed	Comp.	10%	AB	302821

SWITCHES

SW1	Power Switch, SPST Toggle	BB	260134

TRANSFORMERS

T1	Power	117/220 v Primary	SR	120014

TRANSISTORS

Q1	2N176	-11 v Series Regulator	DE	156004
Q2	2N554	Darlington Transistor	DE	156009

VACUUM TUBES

V1	5651	Voltage Reference	TS	154052
V2	6AU6	-210 v DC Amplifier	WH	154022
V3A	1/2-6080	+95 v Series Regulator	TS	154056
V3B	1/2-6080	-210 v Series Regulator	TS	154056
V4	6AU6	+95 v DC Amplifier	WH	154022
V5	12B4	+250 v Series Regulator	TS	154045
V6	6AU6	+250 v DC Amplifier	WH	154022

CAPACITORS

C101	22 uuf	500 v	Tub.	10%	ER	281511
C102	22 uuf	500 v	Tub.	10%	ER	281511
C103	22 uuf	500 v	Tub.	10%	ER	281511
C104	12 uuf	500 v	Tub.	10%	ER	281505
C105A	7-45 uufd		Var.	10%	ER	281012
C105B	82 uufd	500 v	Tub.	10%	ER	281528
C105C	.001 ufd)					
C105D	.01 ufd)	matched timing capacitors			EX	295214
C105E	.1 ufd)					
C105F	1. ufd)					
C106	.001 ufd	500 v	Discap		RMC	283000
C107	.01 ufd	500 v	Discap		RMC	283005
C108	4.7 ufd	500 v	Tub.	10%	ER	281501
C109	.01 ufd	500 v	Discap		RMC	283005
C110	.001 ufd	500 v	Discap		RMC	283000
C111	22 uufd	500 v	Tub.	10%	ER	281511
C112	.001 ufd	500 v	Discap		RMC	283000
C113	22 uufd	500 v	Tub.	10%	ER	281511
C114	47 uufd	500 v	Tub.	10%	ER	281519
C115	47 uufd	500 v	Tub.	10%	ER	281519
C116	.01 ufd	500 v	Discap		RMC	283005
C117	22 uufd	500 v	Tub.	10%	ER	281511
C118	22 uufd	500 v	Tub.	10%	ER	281511
C119A	3-12 uufd		Var.	10%	ER	281007
C119B	7-45 uufd		Var.	10%	ER	281012
C119C	82 uufd		Tub.	10%	ER	281528
C119D	.001 ufd)					
C119E	.01 ufd)	matched timing capacitors			EX	295214
C119F	.1 ufd)					
C119G	1. ufd)					
C120	.01 ufd	500 v	Discap	10%	RMC	283005
C121	.01 ufd	500 v	Discap	10%	RMC	283005
C122	7-45 uufd		Var.	10%	ER	281012
C123A	7-45 uufd		Var.	10%	ER	281012
C123B	47 uufd	500 v	Tub.	10%	ER	281519
C123C	.001 ufd)					
C123D	1. ufd)	matched timing capacitors			EX	295214
C124	7-45 uufd		Var.	10%	ER	281012

DIODES

D101	CD1541	400 v	CD	152010
D102	IN662		CD	152017
D103	TI-55		TI	152009
D104	TI-55		TI	152009
D105	CD1541	400 v	CD	152010
D106	CD1541	400 v	CD	152010
D107	CD1541	400 v	CD	152010
D108*	CD1541	400 v	CD	152010
D109	TI-55		TI	152009
D110	TI-55		TI	152009
D111	TI-55		TI	152009

*selected for low leakage

BULBS

B101	A060	60 v	Neon (Aged and Polarized)		SG	150010

RESISTORS

R101	120 K	1/2W	Fixed	Comp.	10%	AB	302124
R102	210 K	1/2W	Fixed	Prec.	1%	CR	309126
R103	47.5 K	1/2W	Fixed	MF	1%	IRC	310593
R104	100 ohm	1/2W	Fixed	Comp.	10%	AB	302101
R105	22 K	1W	Fixed	MF	5%	CNG	310751
R106	332 K	1/2W	Fixed	MF	1%	IRC	310601
R107	100 K	1/2W	Fixed	MF	1%	IRC	310590
R108	8.25 K	1/2W	Fixed	MF	1%	IRC	310604
R109	680 ohm	1/2W	Fixed	Comp.	10%	AB	302681
R110	3 K	1W	Fixed	Comp.	5%	AB	303302
R111	A&B&C 30K/30K/30K	4W	Var.	WW	CYCLES/SEC	CL	311020
R112	1.2 M	1/2W	Fixed	Prec.	1%	CR	309149
R113	12 M	1/2W	Fixed	Prec.	1%	CR	309267
R114	60 M	2W	Fixed	Prec.	1%	CR	310731
R115	60 M	2W	Fixed	Prec.	1%	CR	310731
R116	182 K	1/2W	Fixed	MF	1%	IRC	310598
R117	47 K	1/2W	Fixed	Comp.	10%	AB	302473
R118	3.3 M	1/2W	Fixed	Comp.	10%	AB	302335
R119	100 K	1/2W	Fixed	MF	1%	IRC	310590
R120	100 ohm	1/2W	Fixed	Comp.	10%	AB	302101
R121	15 K	5W	Var.	WW	RAMP DC LEVEL	CTS	311013
R122	10 K	5W	Fixed	WW	5%	WL	308054
R123	15 K	5W	Var.	WW	RAMP LENGTH	CTS	311013
R124	150 K	1/2W	Fixed	MF	1%	IRC	310594
R125	150 K	1/2W	Fixed	MF	1%	IRC	310594
R126	47 K	2W	Fixed	Comp.	10%	AB	306473
R127	47 K	1/2W	Fixed	Comp.	10%	AB	302473
R128	1.5 M	1/2W	Fixed	Comp.	10%	AB	302155
R129	4.75 K	1/2W	Fixed	MF	1%	IRC	310599
R130	1 K	1/2W	Fixed	MF	1%	IRC	310605
R131	50 K	2W	Var.	(PART OF ± DC LEVEL SW 105)		CTS	311025
R132	22 K	1W	Fixed	MF	5%	CNG	310751
R133	100 K	2W	Var.	Comp.	OUTPUT ATTEN.	AB	311026
R134	15 K	5W	Var.	WW	MIN. AMP. DC BALANCE	CTS	311013
R135	15 K	5W	Fixed	WW	5%	WL	308108
R136	4 K	5W	Fixed	WW	5%	WL	308102
R137	30 K	5W	Fixed	WW	5%	WL	308101
R138	22 M	1/2W	Fixed	Comp.	10%	AB	302226
R139	180 K	1/2W	Fixed	Comp.	10%	AB	302184
R140	56 K	1/2W	Fixed	Comp.	10%	AB	302563
R141	15 K	1W	Fixed	Comp.	10%	AB	304153
R142	150 K	1/2W	Fixed	Prec.	1%	CR	309049
R143	150 K	1/2W	Fixed	Prec.	1%	CR	309049

RESISTORS (cont.)

R144	100 K	1/2W	Fixed	Prec.	1%	CR	309045
R145	100 K	1/2W	Fixed	Prec.	1%	CR	309045
R146	100 ohm	1/2W	Fixed	Comp.	10%	AB	302101
R147	100 ohm	1/2W	Fixed	Comp.	10%	AB	302101
R148	27 K	1W	Fixed	Comp.	10%	AB	304273
R149	2.7 K	1W	Fixed	Comp.	10%	AB	304272
R150	12 K	1W	Fixed	Comp.	10%	AB	304123
R151	200 K	1W	Fixed	MF	5%	CNG	310738
R152	39 K	1/2W	Fixed	Comp.	10%	AB	302393
R153	56 K	1/2W	Fixed	Comp.	10%	AB	302560
R154	47 K	1/2W	Fixed	Comp.	10%	AB	302473
R155	68.1 K	5W	Fixed	WW	5%	SPR	310625
R156	475 K	1/2W	Fixed	MF	1%	IRC	310602
R157	130 K	1/2W	Fixed	MF	1%	IRC	310611
R158	100 K	1/2W	Fixed	Comp.	10%	AB	302104
R159	220 K	1W	Fixed	MF	5%	CNG	310726
R160	15K	5W	Fixed	WW	5%	WL	308108
R161	15 K	5W	Var.	WW	TIMING	CTS	311013
R162	100 ohm	1/2W	Fixed	Comp.	10%	AB	302101
R163	100 ohm	1/2W	Fixed	Comp.	10%	AB	302101
R164	100 K	1/2W	Fixed	Comp.	10%	AB	302104
R165	50 K	1/4W	Var.	Comp.	SQ. WAVE AMPLITUDE	CTS	311077
R166	162 K	1/2W	Fixed	MF	1%	IRC	310603
R167	15 K	5W	Var.	WW	SQ. WAVE DC LEVEL	CTS	311013
R168	47 K	2W	Fixed	Comp.	10%	AB	306473
R169	6 M	1/2W	Fixed	Prec.	1%	CR	310720
R170	6 M	1/2W	Fixed	Prec.	1%	CR	310720
R171	60 M	2W	Fixed	Prec.	1%	CR	310731
R172	15 K	5W	Fixed	WW	5%	WL	308108
R173	15 K	5W	Var.	WW	SQ. WAVE SYMMETRY X10	CTS	311013
R174	121 K	1/2W	Fixed	MF	1%	IRC	310591
R175	3 K	1/2W	Fixed	MF	1%	IRC	310622
R176	182 K	1/2W	Fixed	MF	1%	IRC	310598
R177	100 K	1/4W	Var.	Comp.	SQ. WAVE SYMMETRY X1	CTS	311080
R178	100 ohm	1/2W	Fixed	Comp.	10%	AB	302101
R179	100 ohm	1/2W	Fixed	Comp.	10%	AB	302101
R180	100 ohm	1/2W	Fixed	Comp.	10%	AB	302101
R181	301 K	1/2W	Fixed	MF	1%	IRC	310595
R182	100 ohm	1/2W	Fixed	Comp.	10%	AB	302101
R183	100 ohm	1/2W	Fixed	Comp.	10%	AB	302101
R184	121 K	1/2W	Fixed	MF	1%	IRC	310591
R185	15 K	5W	Var.	WW	A SINE SHAPE	CTS	311013
R186	182 K	1/2W	Fixed	MF	1%	IRC	310598
R187	200 K	1/2W	Fixed	MF	1%	IRC	310615
R188	15 K	5W	Var.	WW	MILLER DC BALANCE	CTS	311013

RESISTORS (cont.)

R189	22.1 K	1/2W	Fixed	MF	1%	IRC	310626
R190	82 K	1/2W	Fixed	Prec.	1%	CR	309117
R191	50 K	1/4W	Var.	Comp.	TRI DC LEVEL	CTS	311077
R192	165 K	1/2W	Fixed	Prec.	1%	CR	309050
R193	15 K	5W	Var.	WW	B SINE SHAPE	CTS	311013
R194	1 K	1/2W	Fixed	MF	1%	IRC	310605
R195	1 M	1/2W	Fixed	MF	1%	IRC	310609
R196	82.5 K	1/2W	Fixed	MF	1%	IRC	310616
R197	162 K	1/2W	Fixed	MF	1%	IRC	310603
R198	1.5 M	1/2W	Fixed	MF	1%	IRC	310612
R199	1 K	1/2W	Fixed	MF	1%	IRC	310605
R200	523 K	1/2W	Fixed	MF	1%	IRC	310618
R201	10 K	1/2W	Fixed	MF	1%	IRC	310600
R202	15 K	5W	Var.	WW	C SINE SHAPE	CTS	311013
R203	600 K	1/2W	Fixed	Prec.	1%	CR	309142
R204	150 K	1/2W	Fixed	Prec.	1%	CR	309049
R205	1.5 M	1/4W	Var.	Comp.	TRI. AMP.	CTS	311079
R206	47 K	2W	Fixed	Comp.	10%	AB	306473
R207	121 K	1/2W	Fixed	MF	1%	IRC	310591
R208	50 K	2W	Var.	WW	COSINE X10 BALANCE	CW	311022
R209	1.5 M	1/2W	Fixed	MF	1%	IRC	310612
R210	47 K	2W	Fixed	MF	5%	CNG	310716
R211	121 K	1/2W	Fixed	MF	1%	IRC	310591
R212	121 K	1/2W	Fixed	MF	1%	IRC	310591
R213	50 K	2W	Var.	WW	HOLD OFF DC LEVEL	CW	311022
R214	249 K	1/2W	Fixed	MF	1%	IRC	310624
R215	1.5 M	1/4W	Var.	Comp.	COSINE DC LEVEL	CTS	311079
R216	50 K	1/4W	Var.	Comp.	SINE DC LEVEL	CTS	311077
R217	274 K	1/2W	Fixed	MF	1%	IRC	310597
R218	47 K	2W	Fixed	Comp.	10%	AB	306473
R219	4.75 K	1/2W	Fixed	MF	1%	IRC	310599
R220	2.7 K	1W	Fixed	Comp.	10%	AB	304272
R221	15 K	5W	Var.	WW	COSINE X1 BALANCE	CTS	311013
R222	130 K	1/2W	Fixed	MF	1%	IRC	310611
R223	150 K	1/2W	Fixed	Prec.	1%	CR	309049
R224	120 K	1/2W	Fixed	Prec.	1%	CR	309047
R225	1.2 M	1/2W	Fixed	Prec.	1%	CR	309149
R226	12 M	1/2W	Fixed	Prec.	1%	CR	309267
R227	100 K	1/2W	Fixed	MF	1%	IRC	310590
R228	1 M	1/2W	Fixed	Prec.	1%	CR	309014
R229	2.5 M	1/2W	Fixed	Prec.	1%	CR	309025
R230	560 K	1/2W	Fixed	Comp.	10%	AB	302564

SWITCHES

SW101	DPST	PUSH BUTTON	MANUAL	GR	260247
SW102	3 WAFER, 2 POS., ROTARY		TRIGGER	OAK	260002
SW103	9 WAFER, 7 POS., ROTARY		MULTIPLIER	OAK	260010
SW104	1 WAFER, 5 POS., ROTARY		OUTPUT	OAK	260011
SW105	SPDT ±DC LEVEL (GANGED WITH R131)			CTS	311025

TRANSISTORS

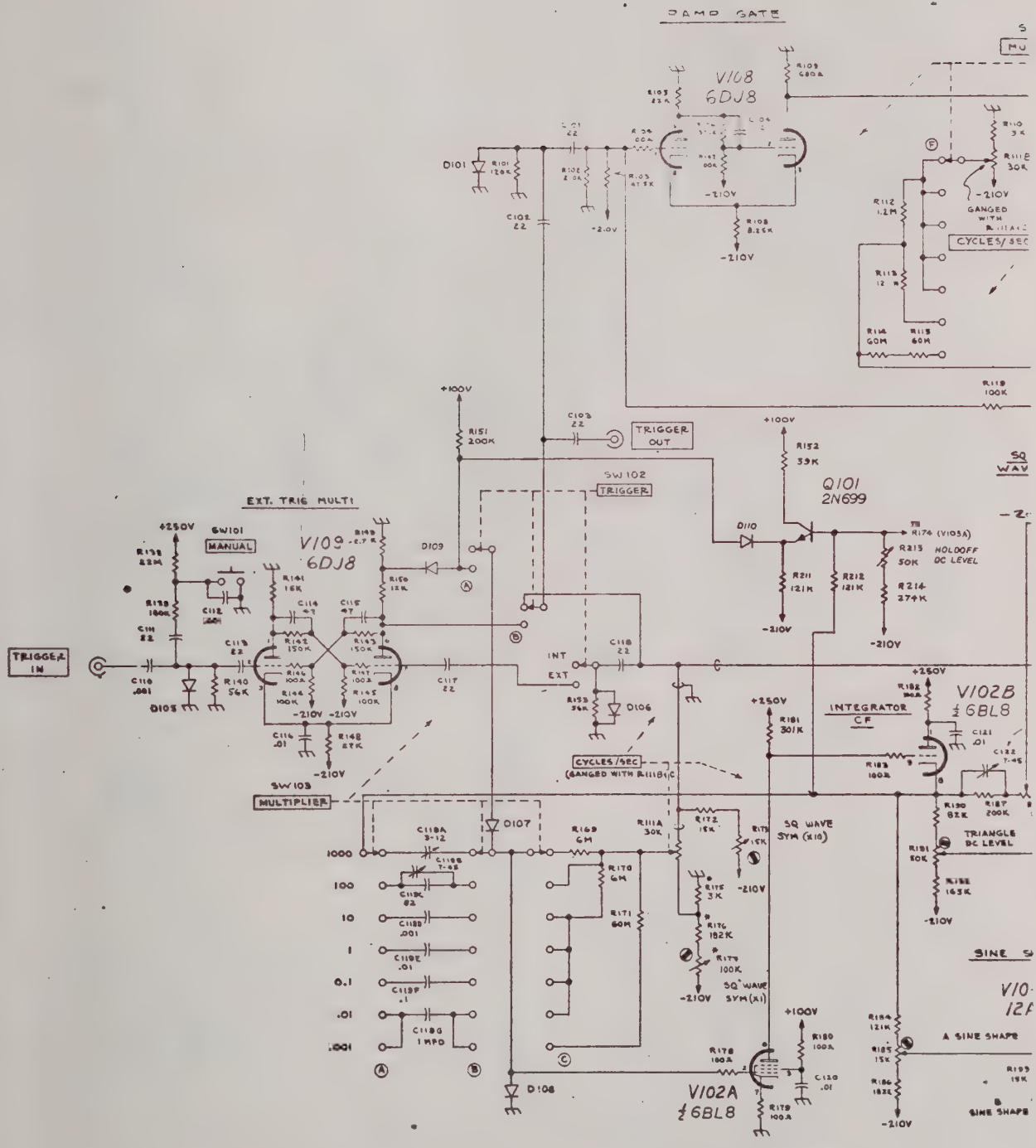
Q101	2N699	HOLD-OFF EMITTER FOLLOWER	TI	156007

TUBES

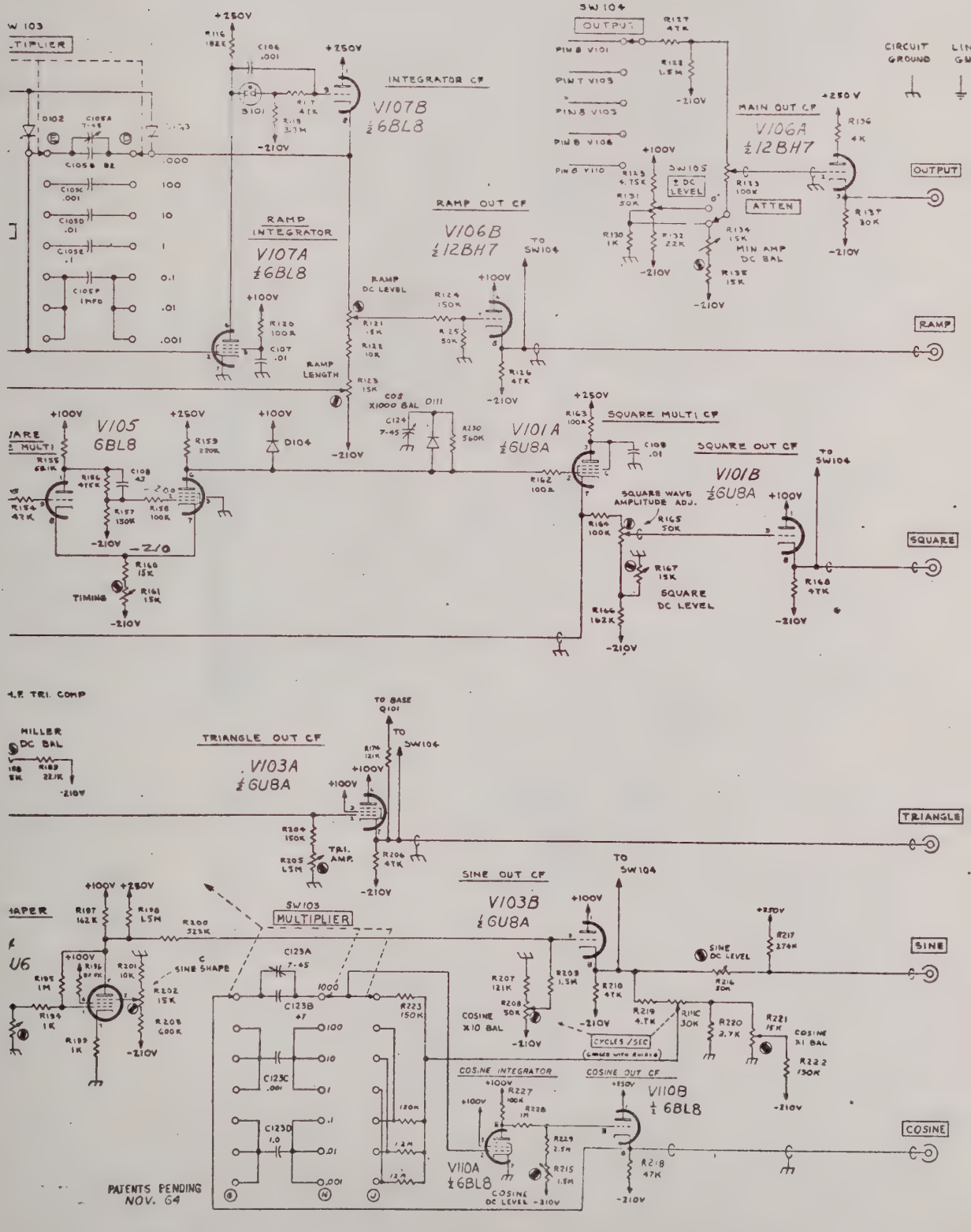
V101A	6U8A	SQ. MULTI CF	AMX	154033
V101B	6U8A	SQ. OUTPUT CF	AMX	154033
V102A	6BL8	MILLER INTEGRATOR	AMX	154057
V102B	6BL8	MILLER INTEGRATOR CF	AMX	154057
V103A	6U8A	TRIANGLE OUT CF	AMX	154033
V103B	6U8A	SINE OUT CF	AMX	154033
V104	12AU6	SINE SHAPER AMPLIFIER	WH	154044
V105	6BL8	SQ. WAVE GENERATOR	AMX	154057
V106A	1/2-12BH7	MAIN OUT CF	WH	154046
V106B	1/2-12BH7	RAMP OUT CF	WH	154046
V107A	1/2-6BL8	RAMP INTEGRATOR	AMX	154057
V107B	1/2-6BL8	RAMP INTEGRATOR CF	AMX	154057
V108	6DJ8	RAMP GATE	AMX	154187
V109	6DJ8	HOLD OFF MULTI	AMX	154187
V110A	1/2-6BL8	COSINE INTEGRATOR	AMX	154057
V110 B	1/2-6BL8	COSINE OUTPUT CF	AMX	154057

SECTION V

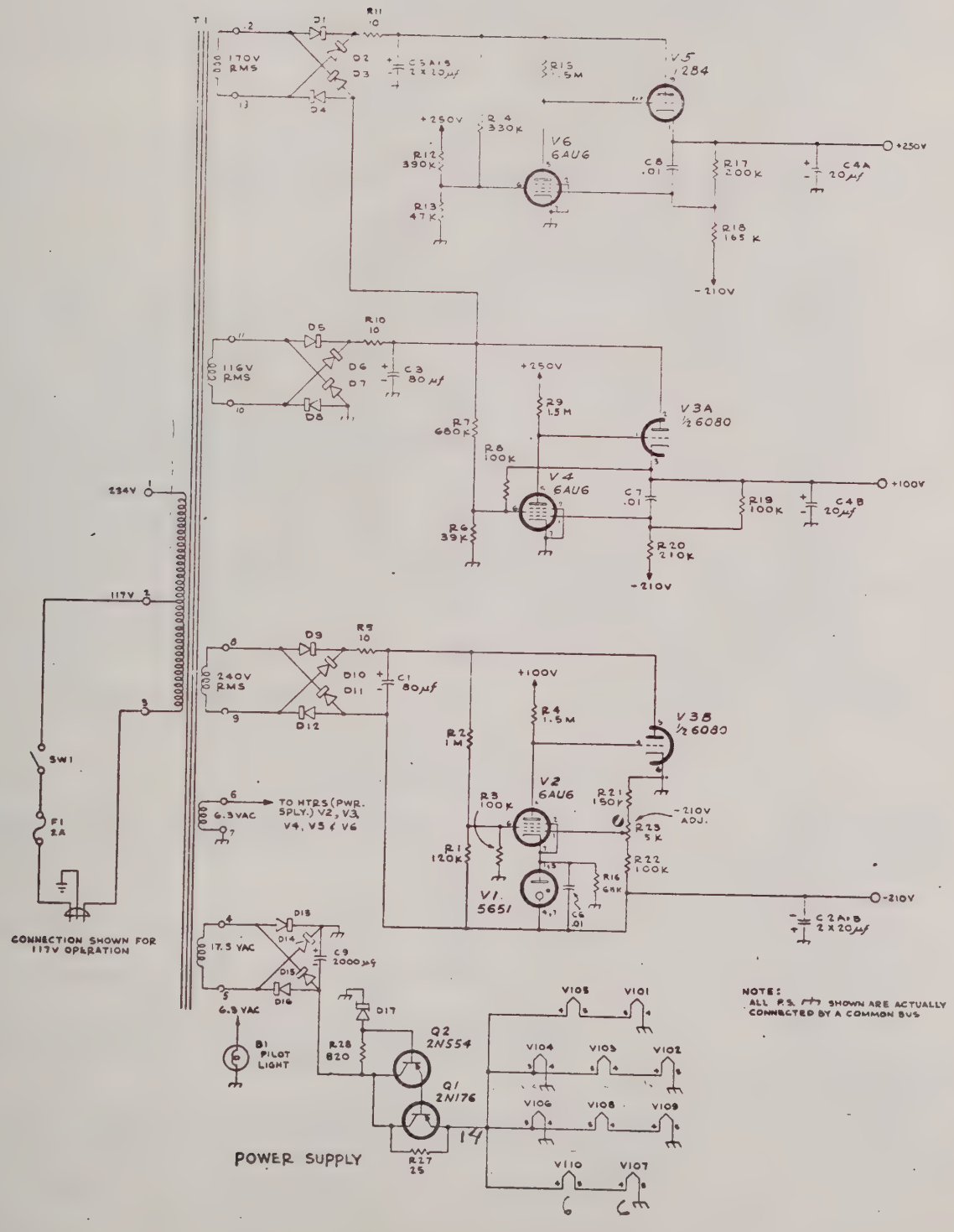
CIRCUIT DIAGRAM



TYPE 251
MAIN GENERATOR



TYPE 251
MAIN GENERATOR (cont.)


T1
D1
R11
10
170V RMS
D2
D3
D4
C5A+B 2 x 20 µf
R15 1.5M
V5 1/2 84
+250V
R4 330K
V6 6AU6
R12 390K
R13 47K
C8 .01
R17 200K
C4A 20 µf
+250V
R18 165 K
-210V
D5
R10 10
D6
D7
D8
116V RMS
C3 80 µf
+250V
R9 1.5M
V3A 1/2 6080
R7 680K
R8 100K
V4 6AU6
C7 .01
R19 100K
C4B 20 µf
+100V
R6 39K
R20 210K
-210V
234V
117V
D9
R5 10
D10
D11
D12
240V RMS
C1 80 µf
+100V
R4 1.5M
V3B 1/2 6080
R2 1M
V2 6AU6
R3 100K
R21 150K
-210V ADJ.
R23 5K
R1 120K
R22 100K
R16 68K
V1 5651
C6 .01
-210V
C2A+B 2 x 20 µf
SW1
F1 2A
6.3 VAC
TO HTRS (PWR. SPLY.) V2, V3, V4, V5 & V6
CONNECTION SHOWN FOR 117V OPERATION
D13
D14
D15
D16
17.5 VAC
C9 2000 µf
6.3 VAC
B1 PILOT LIGHT
D17
R28 820
Q2 2N554
Q1 2N176
R27 25
V105
V101
V104
V103
V102
V106
V108
V109
V110
V107
14
POWER SUPPLY
NOTE: ALL P.S. SHOWN ARE ACTUALLY CONNECTED BY A COMMON BUS

Exact Electronics is represented throughout the world by qualified sales/engineering representatives. Many of these firms have fully equipped maintenance and calibration laboratories and you are invited to use their services for both in and out of warranty repair and preventive maintenance.

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*Exact Electronics, Inc., Hillsboro, Oreg., USA (503)648-6661 (collect)	Alta. & B.C.

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*S. Sterling Co., Cleveland, Ohio (216)442-8080	Eastern Ohio
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*J. T. Hill Co., El Monte, California (213)287-9633	S. Calif. & Nev.
Hytronic Measurements Inc., Denver, Colorado (303)733-3701	Colo., Wyo. & Nebraska
Hytronic Measurements Inc., Salt Lake City, Utah (801)466-4924	Idaho & Utah
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MAINTENANCE & CALIBRATION SERVICES

*Indicates representatives with "in-office" repair facilities.

The following firms are qualified warranty and maintenance repair facilities for the areas indicated. They have been fully trained by Exact and stock the necessary replacement parts.

Vitro Laboratories, Silver Spring, Maryland (301)942-7200	Virginia, Md., & Wash. D.C.
Lockheed Electronics Co., Clark, New Jersey (609)388-4400	New York, New Jersey, & Penna.
SIMCO Electronics, Sunnyvale, California (408) 736-0322	No. Calif.
Instrumentation Services, Inc., Minneapolis, Minnesota (612)521-8803)	Minnesota